AIR FORCE
PROPOSAL PREPARATION INSTRUCTIONS

The responsibility for the implementation and management of the Air Force SBIR Program is with the Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio. The Air Force SBIR Program Executive is R. Jill Dickman, (800) 222-0336. **DO NOT** submit SBIR proposals to the AF SBIR Program Executive under any circumstances. Addresses for proposal submission and numbers for administrative and contracting questions are listed on the following pages, AF-2 through 4.

Technical questions may be requested using the DTIC SBIR Interactive Technical Information System (SITIS). For a full description of this system and other technical information assistance available from DTIC, please refer to section 7.1 of this solicitation.

Air Force Nine-Month Phase I Contract

For the Air Force, the contractual period of performance for Phase I shall be nine (9) months, and the price shall not exceed $100,000. No proposal with a contractual period of performance less than nine (9) months shall be considered.

The primary research must be accomplished during the first six months of the contract. The price of the primary research in the first six months will not exceed $80,000. It is the bulk of the research for the Phase I effort. The primary research effort, alone, is used to determine whether the AF will request a Phase II proposal. The proposal, alone, including Fast Track applications, shall decide who will be selected for Phase II. Our evaluation of the primary research effort and the proposal will be based on the factors listed in section 4 of the solicitation, in the following descending order of importance: a) the soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution; b) the qualifications of the proposed principal/key investigators, supporting staff, and consultants (qualifications include not only the ability to perform the research and development but also the ability to commercialize the results) and c) the potential for commercial (government or private sector) application and the benefits expected to accrue from this commercialization. The actual assigned weightings will not be disclosed outside of the DoD. It is noted that where technical evaluations are essentially equal in merit, and as cost and/or price is a substantial factor, cost to the government will be considered in determining the successful offeror.

Phase II proposals are by invitation only. (All Fast Track applicants will be invited.) If requested, the Phase II proposal must be submitted within six months from the start of Phase I to ensure that the proposal will be evaluated and is eligible for award. After the first six months, additional related research must be conducted that furthers the Phase I effort and puts the small business in a better position to start Phase II, if awarded. The last three months of the nine-month technical effort will not be considered in the evaluation process leading to Phase II awards.

The last three months of the nine-month Phase I contract will provide project continuity for all Air Force Phase II award winners so no modification to the Phase I contract should be necessary. The Air Force will accept proposals for modifications to maintain project continuity under special circumstances such as Fast Track.

Commercial Potential Evidence

A Phase I or II proposal's commercial potential can be evidenced as follows: 1) the small business concern's record of commercializing SBIR or other research, particularly as reflected in its Company Commercialization Report (Appendix E); 2) the existence of second phase funding commitments from private sector or non-SBIR funding sources; 3) the existence of third phase follow-on commitments for the subject of the research and 4) the presence of other indicators of commercial potential of the idea, including the small business' commercialization strategy.

Air Force Cost Proposal

The Air Force anticipates that pricing of this action will be based on adequate price competition. Proposals, including costs, are limited to 25 pages. However, if you are selected to receive an award, be prepared to submit further documentation to substantiate costs in the event that it is either subsequently determined that adequate price competition does not exist or that further information is necessary to facilitate the contracting process.

Air Force Fast Track

Detailed instructions on the Air Force Fast Track and Phase II proposals consistent with this solicitation will be made available by the awarding Air Force activity at the time of Phase I contract award.

PROPOSAL SUBMISSION INSTRUCTIONS

For each Phase I proposal, send one original and four (4) copies to the office designated below. Be advised that any overnight delivery may not reach the appropriate desk within one day. Be sure to read the Air Force instructions on the previous page for the nine-month Phase I contract to avoid the rejection of your proposal. To request notification of proposal receipt, send request (Ref A on page Ref 1) with a self-addressed stamped envelope. Do not call to ask whether your proposal has been received; due to time constraints, we will not be able to answer such telephone calls.

TOPIC NUMBER	ACTIVITY/MAILING ADDRESS (Name and number for mailing proposals and for administrative questions)	CONTRACTING AUTHORITY (For contract questions only)
AF99-001 thru AF99-026	Directed Energy Directorate AFRL/DE 3550 Aberdeen Ave SE, Bldg 497, Rm 239 Kirtland AFB NM 87117-5776 (Robert Hancock, (505) 846-4418)	Sam Berdin (505) 846-1097
AF99-029 thru AF99-079 and AF99-331 -- *EXCEPT for the six topics listed immediately below*	Space Vehicles Directorate AFRL/VS 3550 Aberdeen Ave SE, Bldg 497, Rm 239 Kirtland AFB NM 87117-5776 (Robert Hancock, (505) 846-4418)	Francisco Tapia (505) 846-5021
AF99-033, AF99-040, AF99-053, AF99-067, AF99-069, AF99-073	Space Vehicles Directorate AFRL/VSOT Bldg. 1107, Room 242 29 Randolph Road Hanscom AFB, MA 01731-3010 (Noreen Dimond, (781) 377-3608)	John Flaherty (781) 377-2529
AF99-082 thru AF99-104	Human Effectiveness Directorate AFRL/HE 2509 Kennedy Circle, Rm 161 Brooks AFB TX 78235-5118 (Belva Williams, (210) 536-5429)	Don Norville (210) 536-6393
AF99-107 thru AF99-144	Information Directorate AFRL/IF 26 Electronic Parkway Rome NY 13441-4514 (Jan Norelli, (315) 330-3311)	Joetta Bernhard (315) 330-2308
AF99-145 thru AF99-178	Materials & Manufacturing Directorate AFRL/MLOP 2977 P St, Rm 418, Ste 13, Bldg 653 Wright-Patterson AFB OH 45433-7746 (Sharon Starr, (937) 656-9221)	Terry Rogers (937) 255-5830 Bruce Miller (937) 255-7143
AF99-179 thru AF99-197	Munitions Directorate AFRL/MNOB 101 W Eglin Blvd, Ste 140 Eglin AFB FL 32542-6810 (Richard Bixby, (850) 882-8591x1281)	Lorna Tedder (850) 882-4294 x3399

AF99-204 thru AF99-230 -- *EXCEPT for the nine topics immedicately below*	Propulsion Directorate AFRL/PROP 1950 Fifth St, Bldg 18 Wright-Patterson AFB OH 45433-7251 (Dottie Zobrist, (937) 255-6024)	Terry Rogers (937) 255-5830 Bruce Miller (937) 255-7143
AF99-204, AF99-211 thru AF99-216, AF99-218, and AF99-219	Propulsion Directorate AFRL/PROP (Sandi Borowiak) 5 Pollux Drive Edwards AFB, CA 93524-7033 (Sandi Borowiak, (805) 275-5617)	Donna L. Thomason (805) 277-3900 x2277
AF99-235 thru AF99-263	Sensors Directorate AFRL/SNOX 2241 Avionics Cir. Rm N2S24, Bldg 620 Wright-Patterson AFB OH 45433-7320 (Marleen Fannin, (937) 255-5285x4117)	Terry Rogers (937) 255-5830 Bruce Miller (937) 255-7143
AF99-265 thru AF99-280	Air Vehicles Directorate AFRL/VAOP 2130 Eighth St, Suite 1 Bldg 45, Rm 219 Wright-Patterson AFB OH 45433-7542 (Madie Tillman, (937) 255-5066)	Douglas Harris (937) 255-4427
AF99-284 thru AF99-292	Warner Robins ALC WR-ALC / TIECT 420 Second Street, Suite 100 Robins AFB GA 31098-1640 (Cpt. Bill Braasch, (912) 926-6617)	Cheryl Ficklin (912) 926-9086
AF99-293 thru AF99-299 AF99-307 AF99-324 AF99-326	Air Armament Center AAC/XPP 101 W. D Avenue, Suite 129 Eglin AFB FL 32542-5495 (Dave Uhrig, (850) 882-8096)	Lt. Tim Scarborough (850) 882-8567
AF99-300 thru AF99-306 AF99-325 AF99-330	Air Force Flight Test Center AFFTC / XPST 195 East Popson Avenue Edwards AFB CA 93524-6843 (Abe Atachbarian, (805) 275-9266)	Donna Thomason (805) 277-3900 x2277
AF99-308 AF99-310 AF99-328	Ogden ALC OO-ALC / TIET 5851 F Avenue Hill AFB UT 84056-5713 (Bill Wassink, (801) 777-2977)	Martha Scott (801) 777-0199
AF99-312	46TG/XPX 872 Dezonia Road Holloman AFB NM 88330-7714 (John Cao, (505)475-1228)	Elizabeth Gordon (505) 475-1245
AF313 thru AF99-319	Arnold Engineering Development Center AEDC/DOT 1099 Avenue C Arnold AFS TN 37389-9011 (Kevin Zysk, (931)454-6507	Gloria Fairchild 931-454-7843

AF99-323	Oklahoma City ALC OC-ALC / TIET 3001 Staff Drive Suite 2AG70A Tinker AFB OK 73145-3040 (Don Boedeker, (405) 736-5567)	David Cricklin (405) 739-4468

AIR FORCE 99.1 TOPIC INDEX

AF99-058	Automatic Test Pattern Generation (ATPG) Tool Development
AF99-059	Transportable Standard IR Calibration Source
AF99-060	Emerging Technologies in Training Development
AF99-061	Advanced Cryocooler Technology
AF99-062	Space Vehicles Technology Development
AF99-063	Self-Consuming Satellite
AF99-064	MEMS Integration for Micro-SpacecrAFt
AF99-065	Thermal Management for Advanced Packaging in Payload Electronics
AF99-066	Autonomous Control of Multiple Satellites Using Intelligent Software Agents
AF99-067	Advanced Diagnostic and Modeling Techniques for the Ionosphere and Upper Atmosphere
AF99-068	Power Distribution Architectures for Miniature SpacecrAFt
AF99-069	Innovative Measurement Techniques for Space-Based Remote Sensing/Standoff Detection
AF99-070	Thin Film Flexible, Li-Based Batteries for Space
AF99-071	Latching Microrelays in Thin Plastic Material Systems
AF99-072	Integrated Power Cell
AF99-073	Advanced Algorithms for Exploitation of Space-Based Imagery
AF99-074	Satellite Local Area Network (LAN)
AF99-075	Development of an Integrated Autonomous Optical Imaging Polarimeter-on-a-Chip
AF99-078	Self-Aligning High Density Connectors
AF99-079	Micro Alignment Manipulator Architectures (MAMAs)
AF99-331	Distributed Beam Steering Controller

HUMAN EFFECTIVENESS DIRECTORATE, BROOKS AFB TX

AF99-082	Training for Space Operators Using a Distributed Mission Training Environment
AF99-083	Modeling and Simulation of Less Than War Scenarios
AF99-084	Next Generation Distributed Joint Aircrew Training Effectiveness
AF99-085	Low-Cost Collimating Screen Materials for Out-the-Window Simulator Displays
AF99-086	Advanced Controls and Displays for Space Operator Consoles
AF99-087	Imagery Analyst Interface for Ultra-Spectral Imaging Sensors
AF99-088	Path Intercept Trajectory Algorithm
AF99-089	Human Representation in System Requirements Definition Process
AF99-090	Advanced Multifunction Head-Up Display (AMHUD)
AF99-091	Advanced Virtual Human Sensory Interfaces
AF99-092	Compact Ultrashort Laser Sources
AF99-093	Advanced Battery For Head and Helmet Mounted Night Vision Devices
AF99-094	Development of Life Support Ensemble Utilizing Smart Materials
AF99-095	Altitude Decompression Sickness Risk Assessment Computer (ADRAC)
AF99-096	Distributed Team Knowledge Representation and Scenario-Based Performance Evaluation Methods
AF99-097	Training Management Decision System for Team Training Evaluation and Tracking
AF99-098	Development of Predictive Model for Rocket Launch Noise Footprint
AF99-099	Logistics Technology for Weapon System Support
AF99-100	Impact Injury Modeling Software and Interfacing for the Biodynamic Work Environment
AF99-101	Human Interface Solutions for Emergency Escape System
AF99-102	Advanced Methods for Displaying Large Schematics on Small Screen Devices
AF99-103	Advanced Audio Interfaces
AF99-104	Adaptive Eye Protection

INFORMATION DIRECTORATE, ROME NY

AF99-107	Innovative Information Technologies
AF99-108	Threat Prediction Fusion
AF99-109	Measures of Effectiveness for Abstract Data Fusion
AF99-110	High Throughput Volumetric Memories
AF99-111	Computer Forensics
AF99-112	Communication Performance Measurement for the Mobile User
AF99-113	Internet Protocol (IP) over Asynchronous Transfer Mode (ATM) through Narrowband Common Data Link (CDL)
AF99-114	Distributed Collaborative Modeling and Simulation
AF99-115	Multiple Simultaneous User Interface Technologies For C4I Systems

AF99-116	Mixed-Resolution Modeling and Simulation for JWARS
AF99-117	Time Critical Command and Control (C2)
AF99-119	Tools and Techniques for Advanced Knowledge Discovery
AF99-121	Intrusion Detection And Monitoring Of Large-Scale Networks
AF99-122	Dynamic Data Intensive Intelligent Technology
AF99-123	Flexible Information Extraction Learning Algorithm
AF99-124	Improved Response to Time Critical Targets
AF99-126	Data Classification Algorithms
AF99-127	Adaptive Data Rate Control for Satellite Downlink
AF99-128	Evaluation Tool for Satellite Communication Networks Providing Guaranteed Quality of Service
AF99-129	Reduced-Complexity Receivers for GMSK Modulation
AF99-130	Turbo Code Decoders
AF99-132	High Throughput Terminal/CDMA Modem for Satellite Communications
AF99-133	Universal Data Compression Technology
AF99-134	Generic Intelligent User Interface Agent
AF99-136	Intelligent Web Assistant
AF99-137	Complex Modeling of Software Components
AF99-138	VHDL Based ULSI to VLSI Design Partitioning Tool
AF99-139	VHDL Text-to-Graphics Translation and Text/Graphics Co-Simulation
AF99-140	Immersive Wargaming
AF99-141	Defensive Information Operations Planning Tool
AF99-142	Media and Medium Control for Optimized Internetworking
AF99-143	DII COE Component Framework
AF99-144	Rapid Prototyping Environment for Information System Design and Acquisition

MATERIALS & MANUFACTURING DIRECTORATE, WRIGHT-PATTERSON AFB OH

AF99-145	Low Temperature Compression Set Resistant O-ring Material
AF99-146	Development of Static Dissipative Hard Laminate Surfaces
AF99-147	Removal of Oxide Films from Nickel Based Superalloy Fracture Surfaces
AF99-148	High Temperature Structural Materials for Advanced Space, Missile, and AircrAFt Systems
AF99-150	Lightweight Metallic and Metallic Composite Materials for AircrAFt and Space
AF99-152	Laser Radar Techniques for Multi-Station Vibration Monitoring
AF99-154	Web-based Process Design Agents
AF99-155	Advanced Resin System for RTM/VARTM Processing
AF99-156	Gate-All-Around SOI for Space Applications
AF99-157	Singularity/Boundary Layer Approach for Composite Joints with Discrete Damage
AF99-158	Electrically Conductive, Optically Transparent Polymeric Coating for Canopy ESD Protection
AF99-159	Lubrication in Extreme Environments
AF99-160	Carbon-Reinforced Composites for 550 to 1200 degrees F Applications
AF99-161	Epitaxial Growth of Silicon Carbide (SiC)
AF99-162	High-Efficiency Dynamic Holographic Materials
AF99-163	Materials for Superlattice Infrared Detectors
AF99-164	Absorbing Dyes with Improved Properties
AF99-165	SOI Material for High Reliability Space Systems
AF99-166	Frequency Conversion and Electro-Optical Materials
AF99-167	Novel, Self-Cleaning Filter for Carbonaceous PM2.5 in Combustion Exhausts
AF99-168	Perchlorate Sensing Technology
AF99-169	Advanced Coatings Systems
AF99-171	Novel, Regenerable Filter for Dusts and Sticky Mists
AF99-174	Development of Highly Anti-Reflective Surfaces for Semiconductor WAFers
AF99-175	High Temperature Magnetic Materials
AF99-177	Semiconductor Alloys for Mid-Infrared Applications
AF99-178	Switchable Microlenses for MEMS Applications

MUNITIONS DIRECTORATE, EGLIN AFB FL

AF99-179	Munition Modeling and Technology Integration Research
AF99-180	Ordanance Research
AF99-181	Guidance Research

AF99-182	Control of Large Micro-Eletro-Mechanical Systems (MEMS) Array
AF99-183	High Power Microelectronics Technology
AF99-184	Electrical Disablement of Large Structures and Vehicles
AF99-185	Micro-Electro-Mechanical Systems (MEMS) Technology for System SAFety and Arming
AF99-186	Wireless Data Transmission Through Various Media
AF99-187	Integrated Guidance - Exploitation of Body-Shading for Anti-Jam GPS
AF99-188	Biomimetic Applications for Autonomous Guided Munitions
AF99-189	Multimode/Multispectral Seeker Autonomous Target Acquisition (ATA) Algorithms
AF99-190	Concrete Building Materials Microstructural Damage Quantification
AF99-191	Non-Linear Optical Techniques for Imaging LADAR Transceivers
AF99-192	LADAR Scene Projection for Hardware-In-The-Loop Testing
AF99-193	Fast Imaging Polarimetry
AF99-194	Visible Wavelength Scene Projection for Hardware-In-The-Loop Testing
AF99-195	Innovative Methods for Improving Strength and Fracture Toughness of Steel
AF99-196	Innovative Techniques for Laser Radar
AF99-197	Electron Bombardment Charge Coupled Devices (EBCCD) Development for LADAR Applications

PROPULSION DIRECTORATE, WRIGHT-PATTERSON AFB OH

AF99-204	Advanced Rocket Propulsion Technologies
AF99-205	Aero Propulsion & Power Technology
AF99-206	Directed Energy Weapon Power Technology
AF99-207	Micro-System Technologies for Advanced Aerospace Vehicle Power Systems
AF99-208	UAV Electrochemical Propulsion Power and Energy Storage
AF99-209	Power Generation and Thermal Management
AF99-210	Advanced Dielectrics and Capacitor Devices
AF99-211	Integral Superconducting Electrical Power Generator for Rocket Turbopumps
AF99-212	High Performance Oxidizer System for Hybrid Missiles
AF99-213	Solar Thermal Rocket Propulsion
AF99-214	Electric propulsion thruster for low power small satellites
AF99-215	Cryogenic Boost Pump with Integral Superconducting Electric Motor
AF99-216	Innovative Design of Pulse Detonation Engines
AF99-217	Multi-Mode Propulsion Technology Development
AF99-218	Nanoreinforced Plastics for Liquid Rocket Engine Components
AF99-219	Optical Measurements in Opaque Media: Combustion Applications
AF99-220	Combustion Efficiency Measurements for Advanced Propulsion Systems
AF99-221	High Heat Sink Jet Fuels, Additives and Test Methods; Chemically Reacting Fuels
AF99-222	Advanced Instrumentation and Simulation Technology for Ramjet/Scramjet Combustors
AF99-223	Gas Turbine Engine Compression System Concepts
AF99-224	Gas Turbine Engine Combustion Instability Prediction
AF99-225	AircrAFt High and Low Pressure Turbine Component Technology - Aerodynamics and Cooling
AF99-226	Gas Turbine Engine Control of Smart Components
AF99-227	Gas Turbine Engine Life Extension through Advanced Control Modes
AF99-228	Gas Turbine Engine Non-Intrusive Instrumentation
AF99-230	Electromagnetic Effects and Reliability of High Power/Pulsed Power Systems

SENSORS DIRECTORATE, WRIGHT-PATTERSON AFB OH

AF99-235	Advanced Receiver Integration By Utilization Of Correlator Output
AF99-236	Methodology For The Assessment Of Multi-Sensor Fusion Targeting Technologies
AF99-237	Laser And Radar Clutter Characterization
AF99-238	Space Based Targeting Technologies
AF99-239	Miniaturization Of Evanescent-Mode Filters
AF99-240	Innovative High Power Microwave/Millimeterwave Device Development For Military Essential Systems
AF99-241	Rf Photonics For Space-Based Application
AF99-242	Reconfigurable Aperture For Sensing And Communication
AF99-243	Enhancements To Near-Field Antenna Measurements
AF99-244	Omnidirectional Hemispherical Phased Array Antenna
AF99-245	Smart-Pixel Turbulence Aberration Correction
AF99-246	Unmanned Aerial Vehicle Antennas

AF99-247	Laser Radar For Long-Range Ranging And Non-Cooperative Identification
AF99-248	Real Time Non-Mechanical Microscanning Techniques
AF99-249	Multispectral Infrared Phenomenology For Combined Threat Warning And Reconnaissance Sensors
AF99-250	Modular, Multi-Discriminanat Electro-Optical Sensors-Munitions To Satellites
AF99-251	Global Positioning System (Gps) Receiver Antenna For Spinning Satellite
AF99-253	Advanced Global Positioning System (Gps) Antenna Technology
AF99-255	Real-Time Multi-Spectral Synthetic Battlespace
AF99-256	"System Of Systems" Network Centric Sensors Simulation Concepts
AF99-257	Air Target Combat Identification Technologies
AF99-258	Surface Target Combat Identification Technologies
AF99-259	Innovative Planning Tool For Urban Electromagnetic Environment Characterization
AF99-263	Subpixel Detection Concepts For Space-Based Infrared Hyperspectral Imaging

AIR VEHICLES DIRECTORATE, WRIGHT-PATTERSON AFB OH

AF99-265	Piezoelectric Actuators in High Strain Field
AF99-266	High Temperature Structure Explosive Joining Development Program
AF99-267	Extreme Environments Support/Space Applications
AF99-268	Deformation Measurement for Conformal Loadbearing Antenna Structure Arrays
AF99-269	Unstable Random Vibration Response of Composite Panels
AF99-271	Nonlinear Flying Qualities and Stability and Control Analysis
AF99-272	Aeromechanics for Future AircrAFt Technology Enhancement
AF99-273	Hypersonic Flow Control
AF99-274	High Temperature, Structural Load Bearing Heat Exchanger Technologies
AF99-275	Instantaneous Temperature Measurement System
AF99-276	Enhanced Conduction, Radiation, and Ionic Heat Transfer for Aerospace Vehicles
AF99-277	Enhanced Dry Chemical Fire-Extinguishing Agents
AF99-278	Advanced Stochastic Techniques for Finite Element Vulnerability, Fatigue, Corrosion Simulation
AF99-279	Active Shock-Boundary Layer Control for Drag Reduction
AF99-280	Innovative Techniques for Prediction and Control of Dynamic Loads

WARNER ROBINS ALC, ROBINS AFB FL

AF99-284	Rapid Charging for Electric Ground Support Equipment
AF99-285	Cleaner for Removing Grease and Heavy Soil from Machine Parts
AF99-286	Portable Accumlated Fatigue Damage Inspection and Imaging System
AF99-287	Hybrid Electric Power System for AircrAFt Loaders
AF99-288	New Material for O-Rings and Seals in Halon 1202 Pressurized Systems
AF99-290	Java Based Automatic Test System and Test Program Set Environment
AF99-291	A Five-Function PCMCIA/CardBUS Device for Diagnostic Testing
AF99-292	Wireless Interface for Automatic Test Systems

AIR ARMAMENT CENTER, EGLIN AFB FL

AF99-293	High Bandwidth Digital Rotating Interface (HI-DRI)
AF99-294	Common Real-Time/Postmission Data System
AF99-295	Munitions Lethality Computational Framework
AF99-297	Object Oriented Damage Prediction and Target Vulnerability Estimation
AF99-298	Mission Level Modeling and Simulation Capability
AF99-299	Off-board Targeting Data Link Simulation Capability
AF99-307	Common Test Instrumentation Kit (TIK)
AF99-324	Advanced Multi-function Integrated Target Subsystem (AMITS)
AF99-326	Laser Tracker Location Detection Capability

AIR FORCE FLIGHT TEST CENTER, EDWARDS AFB CA

AF99-300	Bit Rate Agile Onboard Telemetry Formatter
AF99-301	Flutter Suppression System Test Techniques
AF99-302	Instrumentation Network Architecture

AF99-305	Parameter Identification of Short Takeoff and Vertical Landing (STOVL) Aerodynamic Characteristics during Hovering and Transition from/to Wing Borne F
AF99-306	Spectrally Efficient Target Imaging (SETI)
AF99-325	Onboard Smart Sensors
AF99-330	Automatic Conversion of Conventional Tabled Aerodynamic Models

<u>OGDEN ALC, HILL AFB UT</u>

AF99-308	Testing Electronic Circuits Using Atom or Nano Technology
AF99-310	High Speed Digital Timing Sets and Pattern Generator
AF99-328	Avionics Sensor-based System Interoperability with Knowledge-based System Applications

<u>46TG/XPX, HOLLOMAN AFB NM</u>

AF99-312	Automatic Rail Alignment Checker

<u>ARNOLD ENGINEERING DEVELOPMENT CENTER, ARNOLD AFS TN</u>

AF99-313	On-Line Engine Structural Vibrometer for High Cycle Fatigue (HCF) Measurements in Turbine Engines
AF99-314	Temporally and Spatially Resolved Spectrograph for 15-300 keV X-Rays
AF99-315	Fiber Optics Technology Application to Combined Temperature and Stress Measurement
AF99-318	Digital High-Speed Imaging Technologies-Hypersonic Wind Tunnel Support
AF99-319	High Temperature Probe Blade Tip Clearance Measurement System

<u>OKLAHOMA CITY ALC, TINKER AFB OK</u>

AF99-323	IDEF3 Based Training

Department of the Air Force
FY1999 SBIR Topic Descriptions

AF99-001 TITLE: Adaptive Optics Wavefront Compensation Algorithms

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Demonstrate innovative concepts for precise compensation of optical waveforms through turbulent media and from aircraft platforms.

DESCRIPTION: Innovative concepts leading to advanced capabilities in the area of adaptive optics are solicited. These approaches could be useful to programs, such as the Airborne Laser, that require adaptive optics compensation for laser propagation through the atmosphere. The intent is to improve the performance of airborne beam control missions by conceiving and demonstrating innovative concepts for precise compensation of optical waveforms through turbulent media, and from moving platforms looking at moving targets. Innovation is needed in wavefront reconstruction and high frame rate control with the goal of optimizing strehl at the target after propagation through long horizontal paths in an atmosphere with saturated scintillation. Concepts that combine aspects of higher order wavefront compensation with low order tilt compensation will also be considered.

PHASE I: Design innovative adaptive optics approaches and demonstrate that such approaches are feasible for meeting advanced Air Force requirements. Demonstrate the feasibility of producing a demonstration of the adaptive optics concepts, and outline a sound set of demonstration success criteria. Design reviews will cover the individual components, the demonstration architecture, and the control concepts.

PHASE II: Demonstrate the enhanced adaptive optics capabilities based on the approach developed in Phase I. The proposed demonstration can be either ground-based (such as at the Air Force Research Laboratory's Airborne Laser Advanced Concepts Testbed at White Sands Missile Range) or airborne, but in either case should include the effects of both atmospheric turbulence and platform motion.

PHASE III DUAL USE APPLICATIONS: It is expected that an adaptive subsystem based on the concepts proposed under this research, with economical considerations folded in, would have both commercial and military applications. The military applications include all those with requirements for precise atmospheric compensation through turbulent media and from moving platforms to moving targets. The commercial market includes such areas as astronomy, communication, power beaming, and surveying. It is expected that the contractor will concentrate on flexible Phase I designs to maximize commercialization potential.

REFERENCES:

1. Robert K. Tyson and Peter B. Ulrich, "Adaptive Optics", in The Infrared and Electro-Optical Systems Handbook Volume 8, Environmental Research Institute of Michigan, Ann Arbor MI, 1993.
2. Paul H. Merritt et al., Active tracking of a ballistic missile in the boost phase, in SPIE Proceedings Vol. 2739, Acquisition, Tracking, and Pointing, pp.19-29 (1996).
3. Daniel H. Leslie and Douglas G. Youmans, Atmospheric effects on eye-safe airborne laser radar, in SPIE Proceedings Vol. 2375, Beam Control, Diagnostics, Standards, and Propagation, pp.17-29 (1995).
4. Bea et al., Flexible beam expanders with adaptive optics: a challenge for modern beam delivery, in SPIE Proceedings Vol. 2375, Beam Control, Diagnostics, Standards, and Propagation, pp.84-95 (1995).

KEYWORDS: scintillation, anisoplanatism, adaptive optics, wavefront sensor, deformable mirror, optical turbulence

AF99-002 TITLE: High-Power Laser for Long-Range Ranging Applications

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop a modular, scalable laser architecture capable of producing greater than 10 kW of average power when fully scaled.

DESCRIPTION: Systems that use lasers to make measurements at long ranges require lasers with high-average power (>10 kW), good beam quality (M2 < 3), and pulsed operation at repetition rates from 2 to 10 kHz. Due to system power constraints, relatively high efficiency laser technology is required. Many of these applications require field use of the laser systems, so laser systems with relatively small volumes and which can be robustly packaged are desired. Additionally, it is desirable to be able to operate for extended periods of time with minimal use of consumable materials (such as liquids or gasses), so closed-cycle systems are preferred. These many conflicting requirements make it difficult to produce a single system simultaneously satisfying all requirements. Rather than producing a single laser oscillator capable of meeting these system requirements, it may be simpler to combine the optical output of a smaller number of laser "modules" to meet the requirements. An example of such a technology is the master oscillator/power amplifier system described in the literature. A scalable architecture using smaller laser modules is the desired result of this solicitation. Any solutions capable of meeting the specifications will be considered. Such an architecture, if it can be developed, can then be tailored to meet the needs of several different applications without having to redevelop the entire technology base.

PHASE I: Produce a conceptual design of both the laser modules and the scaled system, and analyze the predicted performance and identification of technological risk areas. Laboratory demonstration of the crucial technical concepts and risk areas is desirable and will be a factor in award selection.

PHASE II: Produce and test breadboard laser modules and use them to demonstrate scalability in the laboratory. Combine the laser modules to produce a higher-power laser suitable for field testing.

PHASE III DUAL USE APPLICATIONS: A high-powered, scalable laser technology would be extremely useful to many customers within DoD, including Airborne Laser, Ground-based Laser, and Space-Object imaging efforts within Air Force Space Command. Additionally, a scalable laser architecture could be used to satisfy other DoD and commercial applications with different power requirements. Following successful Phase II demonstrations of the laser modules and scaling techniques, a Phase III program may be initiated to produce a hardened laser capable of being integrated into field experiments. Potential commercial applications would be the industrial manufacturing base where high-power lasers currently are used; the end result of this project could be an industrial laser with higher beam quality than is currently available.

REFERENCES:

1. H. Bruesselbach and D. S. Sumida, "69 W Average Power Yb:YAG Laser", from the OSA Trends in Optics and Photonics, Vol 1, ed S. Payne and C. Pollock, published by the Optical Society of America, 1996, P8.
2. J.R. Unternahrer, M.J. Kukla, R. Burnham, and J. Kasinski, "High Average Power, High Beam-Quality, Unstable-Resonator Slabe Laser", Proc.of the ASSL Conf. V24, Memphis, 1995, P227.
3. A. Giesen, U. Brauch, I. Johannsen, M. Karszewski, U. Schiegg, C. Stewen, and A. Voss, "Advanced Tunabiliy and High-Power TEM00-Operation of the Yb:YAG Thin Disc Laser", Proc.of the ASSL Conf., TOPS V10, Coeur D'Alene, 1997, P280.

KEYWORDS: power amplifier, laser technology, phase conjugation, phase combination, master oscillator, near-infrared lasers

AF99-003 TITLE: Aircraft Electromagnetic Interference Diagnostic and Fault Location System

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop an integrated system capable of identifying internal sources of electromagnetic interference and locating faults within complex electronic systems onboard aircraft.

DESCRIPTION: New generations of aircraft are highly dependent on complex electronic systems to provide not only critical flight functions, but also to perform a multitude of mission functions. Digital electronics are being exploited to provide "glass cockpit" and mission displays combined with fly-by-wire, information processing, and automated control functions to a degree never seen before. This dependence on digital electronics combined with higher clock rates, power conserving signal levels, increased use of composite materials, onboard radar, communications transmitters, and lasers, increases the chances of Electromagnetic Interference (EMI). Current instrumentation used to identify and locate EMI problems has not kept pace with the development of these highly complex systems. Present methods and instrumentation used in EMI tests can be time consuming, labor intensive, intrusive, and difficult, especially for intermittent problems, in a highly automated aircraft with extensive electronic systems.

There is a need for an integrated system with multiple EMI sensors that can be distributed throughout an aircraft and are capable of gathering time and phase correlated data and analyzing the results to determine the sources of EMI and their individual effects on the electronics. Requirements such as these demand integration of the sensors into standard electronics printed architecture. This will allow instrumentation modules to be installed within existing electronics enclosures for the purpose of collecting and processing signals without altering the system electromagnetic characteristics. These instrumentation modules should be capable of interfacing with the electronics back plane and connectors with the characteristic impedance, should emulate board communications functions, and should capture and digitize coupled transients. Individual miniaturized instrumentation modules are also desired for test points that are external to electronic enclosures. This system should also have the capability to generate EMI fields or cable currents that emulate those measured during system level tests to allow testing to be conducted without the need to operate radar, other transmitters or EMI sources to improve safety and efficiency of testing. The integrated diagnostic and fault location system should be highly automated to speed test and keep the number of test personnel to a minimum. The system should also be capable of producing standardized test reports and other documentation with a minimum of individual effort. This approach will reduce costs, speed development time, and allow critical support resources to be conserved.

PHASE I: Analyze potential concepts and perform critical experiments to demonstrate the feasibility of an approach to meet the objectives outlined above. Document the results of these efforts in a report. The report shall also include possible Phase II partnering and an approach for commercialization.

PHASE II: Develop a working prototype system for performing EMI testing of aircraft (large & small) with additional mission electronics and emitters on board. Demonstrate this system on an existing aircraft and compare the results with current EMI testing methods.

PHASE III DUAL USE APPLICATIONS: The EMI test system should be applicable to large and small military and commercial aircraft. Military versions of the system may require special packaging. The system should be easy to use and include testing procedures unique to the system. Self test capabilities should be included along with calibration methods. The system should be automated to produce the final test report with a minimum of operator input.

REFERENCES:

1. Michael M. Marino, Dr. Parviz Parhami, Built-In Test For Electromagnetic Shielding Program,. PL-TR-97-1054, March 1997.
2. Cornet,M.G., Adaptive EMI Reduction for Future Naval ESM Systems
3. Schwegman, C., Southworth, R., Wideband Verification Instrumentation System (WBVIS)
4. Chin, H., Danai,K., Lewicki,D.G., Efficient Fault Diagnosis of Helicopter Gearboxes.

KEYWORDS: fault, sensors, aircraft, hardening, diagnostics, radio frequency, instrumentation, electromagnetic interference (EMI)

AF99-004 TITLE: Tracking through Optical Turbulence

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Demonstrate innovative concepts for tracking laser beacons through optical turbulence where strong scintillation is present.

DESCRIPTION: Innovative concepts leading to advanced capabilities in the area of pointing and tracking are solicited. These approaches could be useful to programs, such as the Airborne Laser, that require precise tracking of laser beacons through optical turbulence where strong scintillation is present. The intent is to conceive and demonstrate innovative concepts for precise stabilization of optical waveforms through turbulent media in order to improve the performance of airborne pointing and tracking missions. We are looking for innovative approaches that more effectively use the information that is available, or where minor hardware changes give significantly improved performance. These approaches can include, but are not limited to: use of multiple apertures, multiple beacons, Kalman filter or other estimators, or transform methods.

PHASE I: Design innovative pointing and tracking approaches and demonstrate that such approaches are feasible for meeting advanced Air Force requirements. Design reviews will cover the individual components, the demonstration architecture, demonstration success criteria, and the control concepts.

PHASE II: Demonstrate the enhanced pointing and tracking capabilities based on the approach developed in Phase I. The proposed demonstration can be either ground-based (such as at the Air Force Research Laboratory's Airborne Laser Advanced Concepts Testbed at White Sands Missile Range) or airborne, but in either case should include the effects of both atmospheric turbulence and platform vibration. It is expected that this phase will provide valuable lessons learned for an Air Force system with requirements for precise pointing and tracking, so that transition is made easily to systems such as the Airborne Laser.

PHASE III DUAL USE APPLICATIONS: It is expected that a pointing and tracking subsystem based on the concepts proposed under this research, with economical considerations folded in, would have both commercial and military applications. The military applications include all those with requirements for precise pointing and tracking through turbulent media and from vibrating platforms, including Airborne Laser, Infrared Countermeasures (IRCM) programs, and directed energy point defense programs such as the Tactical High Energy Laser (THEL). The commercial market includes such areas as laser communication, power beaming, and surveying. It is expected that the contractor will concentrate on flexible Phase I designs to maximize commercialization potential.

REFERENCES:

1. Paul H. Merritt et al., Active tracking of a ballistic missile in the boost phase, in SPIE Proceedings Vol. 2739, Acquisition, Tracking, and Pointing, pp.19-29 (1996).
2. Marcus Schulthess and Steven Baugh, Attitude control a trajectory estimation for the high altitude balloon experiment, in SPIE Proceedings Vol. 2221, Acquisition, Tracking, and Pointing, pp.590-609 (1994).
3. Robert R. Beland, Some aspects of propagation through weak isotropic non Kolmogorov turbulence, in SPIE Proceedings Vol. 2375, Beam Control, Diagnostics, Standards, and Propagation, pp.6-16 (1995).
4. Daniel H. Leslie and Douglas G. Youmans, Atmospheric effects on eye-safe airborne laser radar, in SPIE Proceedings Vol. 2375, Beam Control, Diagnostics, Standards, and Propagation, pp.17-29 (1995).
5. Bea et al., Flexible beam expanders with adaptive optics: a challenge for modern beam delivery, in SPIE Proceedings Vol. 2375, Beam Control, Diagnostics, Standards, and Propagation, pp.84-95 (1995).

KEYWORDS: tilt, tracking, pointing, scintillation, laser propagation, optical turbulence

AF99-005 TITLE: Energy Donor for Iodine Atom Transfer Laser

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop improved singlet delta oxygen generation techniques and/or new energy donor molecules to pump ground state iodine to the electronic excited state.

DESCRIPTION: Singlet delta oxygen is currently used as the energy donor molecule for the Chemical Oxygen Iodine Laser (COIL) device. The singlet delta oxygen generation process involves two-phase gas/liquid chemistry where gaseous chlorine is brought into contact with a liquid electrolyte solution of Basic Hydrogen Peroxide(BHP). The two major drawbacks to this approach are the production of water vapor (which deactivates excited state iodine) and the weight penalty associated with the water in the electrolyte BHP. Obvious approaches to dealing with water production (i.e. use of colder BHP temperature/use of deuterated BHP) have been investigated and found to have problems of their own. The Air Force Research Laboratory (AFRL) is seeking alternate ways of producing singlet delta oxygen at high pressure and high molar flow rates in a manner which has favorable weight scaling for Airborne Laser (ABL) or Space-Based Laser (SBL) applications. Alternately, there is interest in using other energy donors to pump the iodine atom to its excited state. One such approach, using singlet delta nitrogen chloride (NCL) as the donor, is under investigation at the AFRL.

PHASE I: Identify the concept and subscale proof-of-principle experiments. Investigate scaling potential to high flow rates with associated weight.

PHASE II: Develop generator hardware to interface with the RADICL device at the AFRL Phillips Site for testing with power extraction.

PHASE III DUAL USE APPLICATIONS: Commercial applications of COIL technology include industrial strength welding and cutting. This technology would also improve COIL performance for both ABL and SBL applications.

REFERENCES:
1. Madden, T. J. and Solomon W. C., "A Detailed Comparison of a Computational Fluid Dynamic Simulation and a Laboratory Experiment for a COIL Laser," AIAA 96-2354, 28th AIAA Plasmadynamics and Lasers Conference, June 23-25, 1997, Atlanta, GA.
2. Zagidulin, M. V., Nikolaev, V. D., Svistun, M. I., Khvatov, N. A., and Ufimtsev, N. I., "Highly efficient supersonic chemical oxygen-iodine laser with a chlorine flow rate of 10 mmol s-1," Quantum Electronics, 27, (3), pp. 195-199, (1997).

KEYWORDS: energy donor, gas phase energy donor, energy transfer species, metastable energy donors, metastable energy carrier, chemical laser energy donor

AF99-006 TITLE: Non-Evasive In Situ Cable Shielding Tester

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop the capability to allow the electromagnetic shielding properties of aircraft shielded cables to be measured without disconnecting any of the cable connectors or removing the cable from the aircraft.

DESCRIPTION: Testing of aircraft shielded cables requires that one connector of a cable be disconnected or the entire cable removed from the aircraft to measure the electromagnetic shielding properties. This practice is time consuming, costly, and can cause damage to the cable and other components during the process. Commercial aircraft must undergo a re-certification of the cable after it has been disconnected and reinstalled. The goal of this effort is to develop a test capability that will allow the shielding properties of installed cables to be measured without disconnecting any of the cable connectors or removal from the aircraft. The frequencies of interest for this test capability extend from 10 kHz to 500 mHz. The tester must be easily portable and user friendly with minimum operator skills needed to determine pass/fail of the cable shielding.

PHASE I: Perform experiments to determine and demonstrate an approach which can be developed into a prototype system during a Phase II effort that meets the objectives outlined above. Document the approach and information developed during this phase in a report. The report shall also include possible Phase II partners and a commercialization approach.

PHASE II: Develop a working prototype test system and demonstrate its capabilities on one or more aircraft. Self test and built-in calibration capabilities shall be included as appropriate. A means of logging results for later transfer to a central automated data base is also desirable.

PHASE III DUAL USE APPLICATIONS: The shielded cable tester should be useful for either military or commercial aircraft. Different versions of the tester may be needed to meet military handling requirements versus those needed for commercial operations. The system should be easy to use, include testing procedures, and have a self test capability.

REFERENCES:
1. Michael M. Marino, Dr. Parviz Parhami, Built-In Test For Electromagnetic Shielding Program. PL-TR-97-1054, March 1997.
2. Damaskos, N., Kelsall, B., Passive Shielding for Low Frequency Magnetic Fields, 1997.
3. Coonrod,K., Davis, S., McLemore, D. Fault Detection Techniques for Complex Shield Topologies, 1994.
4. Blocher, T., Validation of Shielding Effectiveness of Cables with Pigtails.

KEYWORDS: cable, fault, sensors, aircraft, hardening, shielding, diagnostics, radio frequency, instrumentation, electromagnetic interference (EMI)

AF99-007 TITLE: Tracking/Wavefront Processor for High Bandwidth Control Applications

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop a processor architecture using COTS components that supports high bandwidth control applications.

DESCRIPTION: Advanced beam control systems like the Airborne Laser require high bandwidth control systems with closed loop bandwidths exceeding 1 kHz for control of various tracking loops and wavefront sensing loops. These control systems put a premium on processing in real time at high speeds and also require high-speed read/write memory. This effort will develop a processor architecture that will maximize the use of commercial off-the-shelf components (COTS) and will retain a degree of processor flexibility that will allow new algorithms for different tracking/wavefront control applications to be loaded easily without re-engineering/rebuilding the processor. The design must be able to meet the needs of both tracking and wavefront control applications, and must be flexible enough to add additional throughput/storage capability as needed. The goals for the processor are to support real time processing at 10 kHz frame rates for cameras with 256 x 256 pixels.

PHASE I: Produce a conceptual design for the processor, including architecture, interface definition, timing, data storage, and graphical user interface.

PHASE II: Design and produce a complete processor. This system will be tested with sample algorithms provided by the government, simulating a tracking control system.

PHASE III DUAL USE APPLICATIONS: This processor would be useful to both Airborne Laser and ground-based laser programs, as well as to astronomy applications within DoD and NASA. A processor of this type would be commercially useful in many imaging applications requiring high bandwidth and real time control, including process monitoring and control, high-speed photography, and remote sensing.

REFERENCES:
1. Robert K. Tyson and Peter B. Ulrich, "Adaptive Optics", in The Infrared and Electro-Optical Systems Handbook Volume 8, Environmental Research Institute of Michigan, Ann Arbor MI, 1993.
2. Paul H. Merritt et al., Active tracking of a ballistic missile in the boost phase, in SPIE Proceedings Vol. 2739, Acquisition, Tracking, and Pointing, pp.19-29 (1996).

KEYWORDS: tracking, processor, high-bandwidth, wavefront sensor, real-time control, high-frame rate cameras

AF99-008 TITLE: Advanced Chemical Oxygen-Iodine Laser (COIL) Mixing Nozzles

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop improved approaches for mixing and reacting iodine and singlet delta oxygen flows in COIL devices.

DESCRIPTION: The Air Force Research Laboratory at Kirtland AFB is seeking approaches for development of advanced chemical oxygen-iodine laser (COIL) mixing nozzle concepts. Successful approaches must demonstrate improved performance characteristics over traditional COIL mixing nozzle concepts in one or all of the following aspects of COIL operation: mirror power lading, gain magnitude and distribution, chemical efficiency, and pressure recovery. Traditional COIL mixing nozzles inject molecular iodine/diluent mixtures into the subsonic region of the singlet delta oxygen flow upstream of the nozzle throat, often leading to gain distributions that heavily load the leading edge of the mirrors (seeREFERENCE 1). Studies (seeREFERENCE 2) suggest that one mechanism for alleviating this problem is to inject the molecular iodine/diluent mixture into the supersonic region of the singlet delta oxygen flow, thereby producing a slower gain increase that reduces the power loading on the mirrors. Variations on the supersonic mixing concept offer the possibility of improving the chemical efficiency and pressure recovery of COIL's. One such concept uses parallel mixing of supersonic molecular iodine/diluent and singlet delta oxygen/diluent flows, reducing total pressure loss over traditional transverse molecular iodine/diluent injection mechanisms and improving pressure recovery. Another concept mixes parallel supersonic singlet delta oxygen /diluent and F,HI(DI)/diluent flows. This concept offers the possibility of significantly improved chemical efficiency over traditional COIL devices by using F to produce I in the reaction F + HI (DI) results in HF (DF) + I, thereby eliminating the need to dissociate molecular iodine using singlet delta oxygen. Approaches incorporating some or all aspects of these various concepts are of strong interest to the Air Force in that lighter, more efficient COIL devices may result.

PHASE I: Analyze and develop various COIL mixing nozzle concepts. Concept feasibility should be demonstrated on the basis of mirror loading, gain distribution, chemical efficiency, and pressure recovery predicted by proven models.

PHASE II: Select, fabricate, and test selected concepts in experiments.

PHASE III DUAL USE APPLICATIONS: In addition to Air Force applications, the development of lighter weight and higher chemical efficiency COIL systems has direct pertinence to ongoing efforts to commercialize COIL's. This technology can potentially improve COIL performance for Air Force Airborne Laser applications. Commercial applications include industrial strength welding and cutting. Of particular relevance is the use of less expensive diluents, such as nitrogen, which decrease the cost of COIL operation.

REFERENCES:

1. Madden, T. J. and Solomon W. C., "A Detailed Comparison of a Computational Fluid Dynamic Simulation and a Laboratory Experiment for a COIL Laser," AIAA 96-2354, 28th AIAA Plasmadynamics and Lasers Conference, June 23-25, 1997, Atlanta, GA.

2. Zagidulin, M. V., Nikolaev, V. D., Svistun, M. I., Khvatov, N. A., and Ufimtsev, N. I., "Highly efficient supersonic chemical oxygen-iodine laser with a chlorine flow rate of 10 mmol s-1," Quantum Electronics, 27, (3), pp. 195-199, (1997).

KEYWORDS: COIL mixing, COIL nozzle, iodine mixing, secondary mixing, supersonic mixing, supersonic nozzle

AF99-009 TITLE: Lidar for Remote Sensing of Optical Turbulence

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a lidar-based sensor to measure optical turbulence strength remotely.

DESCRIPTION: Systems that propagate lasers through the atmosphere, such as the Airborne Laser (ABL), are affected by the optical turbulence strength along the path. Currently, there are several optical techniques for measuring vertical profiles of the refractive index structure parameter (Eaton et al., 1988). There are also in situ techniques for obtaining refractive index structure parameter point measurements from probes mounted on aircraft, providing horizontal and slant path information. What is needed is a technique that can remotely obtain point measurements along a propagation path, such as what could be obtained with a lidar (see for example Chan and Killinger, 1992). A lidar operating from the aircraft platform could potentially obtain a three-dimensional map of refractive index structure parameter in the area of interest where the system must operate. Another advantage of a lidar technique is that it could also sense other parameters of interest including cirrus clouds. Innovative approaches to lidar for measuring refractive index structure parameter will be entertained that show promise for both surface and aircraft operation. The approach must exhibit the potential to operate in a "vibration" environment such as with an aircraft platform. Since many of the adaptive optics techniques that were developed by DoD have recently been declassified, many large astronomical observatories are actively pursuing the implementation of adaptive optics for mitigating turbulent effects of long exposure imagery obtained with the large astronomical telescopes. Once these adaptive optics systems are operational, it is highly probable that a lidar that senses refractive index structure parameter and other parameters, such as nighttime cloud conditions, would become a requirement.

PHASE I: Produce a conceptual design for the lidar. Also produce detailed analysis of the predicted performance (range, resolution, dynamic range). A laboratory proof of concept would be a plus, but is not required.

PHASE II: Develop a breadboard lidar system capable of being fielded at the Airborne Laser Advanced Concepts Testbed (ABL ACT) at White Sands Missile Range. This system would be used to obtain refractive index structure parameter profiles over a 51-km horizontal path.

PHASE III DUAL USE APPLICATIONS: Since many astronomical sites are initiating adaptive optics programs, it is likely that a small commercial lidar system, that would provide profile information of refractive index structure parameter and sense thin clouds at night when clouds aren't visible, would also be attractive. A commercial lidar that is maintainable, dependable, and "user friendly" is essential for such operations. A lidar system to remotely measure optical turbulence would be extremely useful to many customers within DoD, including the Airborne Laser, Ground-based Laser, and Space-Object imaging efforts within the Air Force Space Command. Upon a successful Phase II test, it is very likely that a Phase III program would develop that would include integrating a flight-worthy system on board assets such as ARGUS to demonstrate lidar as a Tactical Decision Aid for the Airborne Laser.

REFERENCES:

1. Eaton, F. D., W. A. Peterson, J. R. Hines, K. R. Peterman, R. E. Good, R. R. Beland, and J. H. Brown, "Comparison of VHF Radar, Optical, and Temperature Fluctuation Measurements of refractive index structure parameter, r[subO], and [theta sub O]", Theor. and Applied Climatol., 39, 17-29 (1988).

2. Kin Pui Chan and Dennis K. Killinger, "Coherent 1 micron lidar measurements of atmospheric-turbulence-induced spatial decorrelation using a multi-element heterodyne detector array", Applied Optics, 31, 105, (1992).

KEYWORDS: lidar, cirrus clouds, laser propagation, optical turbulence, site characterization, refractive index structure parameter

AF99-010 TITLE: Acoustic Suppression for Precision Equipment in High-Performance Aircraft Interiors

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop a hardware system to compensate for the detrimental effects of multiple acoustic inputs originating both external and internal to the enclosed volume of an aircraft.

DESCRIPTION: Active noise control has advanced significantly in recent years, but most applications to date have addressed physical systems with relatively limited spatial or temporal complexity. For example, noise is reduced at a single headset location or only for small numbers of sources contributing narrowband or perhaps multi-tonal input. The F-16 aircraft and any use of High Energy Lasers (HEL) represent a highly complex acoustic environment that includes multiple noise sources outside and inside the aircraft and a large number of noise and vibration sensitive precision optical components. High sound pressure levels are potentially present over a broad frequency range, and performance requirements for jitter and alignment on F-16 aircraft are extremely demanding and are distributed over multiple components. Passive means of acoustic compensation are physically limited at low frequency and are not well suited to adapt to changes in the disturbance environment and performance demands during a typical mission. The project will employ advanced noise control techniques that can also be projected to practical automated implementation in an airborne environment with reasonable constraints on weight. The approach could include localized or distributed cancellation, equipment or machinery enclosures, feed-forward and feedback control, active-passive hybrid systems, and coupled vibro-acoustic considerations. The proposer should consider the differences between this development and development for noise suppression in commuter passenger aircraft and should understand the realistic limits of global broadband active noise control.

PHASE I: Demonstrate by analysis, and possibly through supporting test data, a cohesive approach to acoustic compensation for the interior of fighter aircraft with external and internal acoustic sources. Identify a critical high-payoff subsystem technology for further development.

PHASE II: Fabricate an acoustic compensation subsystem and demonstrate its ability to improve substantially the performance of a representative laboratory precision optical system under realistic acoustic amplitude input levels, frequency content, and time-variability. Demonstrate by high fidelity simulation the expected performance improvement for the aircraft environment and provide components for possible flight tests to be conducted by the Air Force.

PHASE III DUAL USE APPLICATIONS: Potential commercial applications include commercial aircraft and other vehicles, active enclosures for precision manufacturing and optical inspection equipment, and suppression of sound in high-density multi-purpose workspaces. Potential military applications include the HEL laser systems on fighter aircraft, other vehicles incorporating precision sensors and instruments, and compensation for reduced personnel fatigue.

REFERENCES:

1. B. Widrow and S. Stearns, "Adaptive Signal Processing," (Prentice-Hall, NY) 1985.
2. P. A. Nelson and S. J. Elliott, "Active Control of Sound," (Academic Press, NY) 1992.
3. S. M. Kuo and D. R. Morgan, "Active Noise Control Systems," (John Wiley & Sons, NY) 1996.

KEYWORDS: aircraft acoustics, high energy lasers, active noise control, high g-factor effects, interior optical disturbances, vibration control in moving aircraft

AF99-011 TITLE: Low-Noise, High-Bandwidth Cameras for Wavefront/Tracking Sensors

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a low-noise SWIR camera for active tracking and wavefront sensing that operates at frame rates in excess of 5 kHz.

DESCRIPTION: Advanced beam control systems like Airborne Laser require high-bandwidth, low-noise cameras for tracking and wavefront sensing. The high bandwidth is required to collect information to feed high bandwidth control loops necessary to compensate for atmospheric effects such as optical turbulence. The noise levels affect the stability of these control loops and ultimately the range of the system. Lower noise performance allows for potential weight reduction on the aircraft due to a reduction in laser power necessary to achieve the designed range. Alternatively, lower camera noise can increase the system performance. The camera needs to operate in the Short Wavelength Infrared (SWIR) region, especially at laser wavelength in the range from 1.4 to 1.06 microns. The current state of the art for near infrared cameras in this wavelength range is video frame rates (60 Hz) with quantum efficiencies less than 10 percent and noise levels of 100 noise electrons per pixels. The goals for this program are frame rates in excess of 5 kHz, quantum efficiencies of better than 50 percent, and noise levels of less than 50 noise electrons per pixel.

PHASE I:Develop a conceptual design for a camera system to include focal plane array design, readout architecture and design, and camera interface control design.

PHASE II: Develop a complete focal plane array with high frame rate readout. The capability of this camera to collect high frame rate tracking data or wavefront data will be demonstrated at either the Airborne Laser Advanced Concepts Testbed at White Sands Missile Range or the Advanced Tracking Lab at Kirtland AFB.

PHASE III DUAL USE APPLICATIONS: A successful Phase II completion would lead to integration of the camera into experimental USAF programs, such as the Airborne Laser Advanced Concepts Testbed, that could be used to demonstrate and transition the technology to the Airborne Laser, the Space-Based Laser, or the Ground- Based Laser Technology Program. On the commercial side, this high frame rate camera would be useful for high-speed photographic applications in the SWIR, including process monitoring, quality control, and automated manufacturing, with potential application in the visible spectrum, especially the high-frame rate readout electronics.

REFERENCES:

1. Paul H. Merritt et al., Active tracking of a ballistic missile in the boost phase, in SPIE Proceedings Vol. 2739, Acquisition, Tracking, and Pointing, pp.19-29 (1996).
2. Marcus Schulthess and Steven Baugh, Attitude control a trajectory estimation for the high altitude balloon experiment, in SPIE Proceedings Vol. 2221, Acquisition, Tracking, and Pointing, pp.590-609 (1994).

KEYWORDS: camera, tracking, infrared, wavefront sensor, optical turbulence, quantum efficiency

AF99-012 TITLE: Advanced High Power/High-Energy Laser Technology Emphasizing Light-Weight, Small Volume, High Efficiency

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop advanced high power/energy laser technology using electrical discharges (and hybrid electro-chemical approaches) with particular emphasis on small weights and volumes.

DESCRIPTION: With the advent of the More Electric Aircraft (MEA), significant electrical power exists on the F-16 for potential use as directed energy weapons like lasers. Since the 1970's, the consensus has been that chemical lasers were the only practical method to acquire high powers at reasonable weights and volumes. On the other hand, electric lasers required large APU's (Auxiliary Power Units) powered by chemicals stored on the aircraft. This requirement produced larger weights for the laser systems, with the APU sometimes making up to 40% of the total weight of the high power laser system. Consequently, until this time, most of the emphasis for high power lasers suitable for military aircraft has been on chemical lasers. With the demonstration of the MEA, this weight issue for electrical lasers is greatly reduced. Concepts using plasmas to sustain lasing may now become much more practical for their use as high power lasers on fighter aircraft. In addition, the use of such plasmas to promote chemical reactions is also important. Previous electrical discharge techniques employing high energy electron beams are not suitable due to the large weights. Possible use of aircraft jet engines to provide the flowing active gaseous laser mediums should be given special attention in order to minimize weights and volumes. Besides gas phase electric lasers, intermediate and lower power approaches involving solid state lasers, fibers, and semiconductors (PILOT) are also important. High peak powers with variable pulsewidths and PRF are attractive for these lower power systems. Efficiency is most important and integration / compatibility with the aircraft is critical. Laser system approaches accounting for possible high g-forces (maybe up to 9) should be followed. Although high powers normally involving gaseous mediums are desired, intermediate levels using solid state lasers, fibers, and semiconductors are also important.

PHASE I:Demonstrate, by analysis and possibly through supporting test data, approaches to produce high, intermediate, and low power electrical lasers (and hybrid electro-chemical) having small volumes/weights compatible with F-16 aircraft and other air platforms. Identify critical high-payoff aspects of the laser subsystem technology for further development.

PHASE II:Fabricate and test new approaches to high, intermediate, and low power laser technology demonstrating small volumes and achievable light weights. Integration of the entire laser system into small volumes compatible with the aircraft is critical. Design concepts accounting for the vibrations and acoustics of the aircraft should also be followed in order to assure good laser beam quality occurs with negligible pointing jitter.

PHASE III DUAL USE APPLICATIONS: Potential commercial applications include commercial aircraft and other vehicles, like ground-based vehicles such as robots for illumination/burning/damaging of hazardous waste (chemicals or radioactive contamination). Potential military applications include the HEL laser systems on fighter aircraft for various applications.

REFERENCES:
1. E. F. Yelden, H. J. J. Seguin, C. E. Capjack, and S. K. Nikumb, "Multichannel Slab Discharge for CO2 Laser Excitation", Appl. Phys. Lett., 58, 693 (1991).
2. J. A. Glaze, J. Finzi, W. F. Krupke, "A Transverse Flow cw HCl Laser", 18, 173 (1971).
3. K. R. Newton and R. B. Bernstein, "Cryosorption-Pumped cw Chemical Laser", Appl. Phys. Lett., 33, 47 (1978).
4. L. J. Mawst, A. Bhattacharya, M. Nesnidal, J. Lopez, D. Botez, J. A. Morris, and P. Zory, "High cw Output Power and Wallplug Efficiency Al-free InGaAs/InGaAsP/InGaP Double Quantum Well Diode Lasers", Electronics Letters, 31, 1153 (1995).
5. C. Kennedy, High Power Diode Pumped Laser Pulse Amplifiers", Lasers and Optronics, pp. 13-15, October 1997.

KEYWORDS: fiber lasers, solid state lasers, semiconductor lasers, laser thermal management, diode pumped solid state lasers, high efficiency electric lasers, electric discharge lasers (EDL's), aircraft based electrical storage, hybrid electro-chemical and chemical lasers

AF99-013 TITLE: Portable UHF or VHF Radar for Measuring Wind and the Refractive Index Structure

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a portable UHF or VHF radar for measuring wind and the refractive index structure parameter.

DESCRIPTION: There is a requirement for a portable UHF or VHF radar that senses wind and the refractive index structure parameter from the lower troposphere to an altitude of 20 km. A range resolution of 150 m is required and the one-way beam width must not exceed 3 degrees. A profile of wind must be sensed at no longer than at three-minute intervals. The power aperture product must be a minimum of 1x100 million Watts per square meter. These radar characteristics are state of the art for permanent installations (see for example Nastrom and Eaton, 1995). Only one VHF radar, a SOUSY radar developed at the Max Planck Institute, was designed with considerations of possibly moving the system, but this has been accomplished only a few times and requires considerable time and manpower (the system is described by Czechowsky et al., 1984). Profilers designed to measure the boundary layer and lower troposphere, typically at 915 MHz, have been successfully engineered for portability. The new UHF or VHF system should be capable of being disassembled within a week, moved to a new site, and reassembled within a week (provided the site has been prepared).

PHASE I: Produce a conceptual design for the portable UHF and VHF radar system. Also, develop a detailed analysis of the predicted performance of each component of the system. Address all electronics, mechanical, and software issues.

PHASE II:Develop and field test a breadboard portable UHF or VHF radar. The performance of this system will be evaluated by comparison with measurements with a TBD system selected by the U.S. Air Force Research Laboratory. Ease of set-up and tear-down of the portable system will be monitored.

PHASE III DUAL USE APPLICATIONS: UHF or VHF radar systems are generally installed once or are moved to a new program with great difficulty and expense. Usually some parts of the system must be replaced since they were permanently installed. Besides the Airborne Laser and ground-based laser programs, other research programs in DoD would benefit with a portable radar system of this type. Several other government agencies would use such a system on research programs and could increase productivity and scope of several studies. On the commercial side, a radar of this type would be useful for air pollution evaluations over moderate times for site characterization studies. It also would be useful to assess wind shear and weather at small airports to determine if a large radar permanent installation is justified as part of a general weather monitoring station due to unique local effects.

REFERENCES:

1. Czechowsky, P., G. Schmidt, R. Ruster, 1984: The Mobile SOUSY Doppler Radar: Technical Design and First Results, Radio Science, 19, 441-450.

2. Nastrom, G. D., and F. D. Eaton, 1995: Variations of Winds and Turbulence as Seen by the 50-MHz Radar at White Sands Missile Range, New Mexico, J. Appl. Meteorol., Vol. 34, No. 10, pp2135-2148.

KEYWORDS: radar, troposphere, stratosphere, wind measurements, site characterization, refractive index structure parameter

AF99-015 TITLE: Portable Differential Image Motion Monitor (DIMM) for Measuring Optical Turbulence

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a Portable DIMM for measuring various optical turbulence parameters.

DESCRIPTION: There is a need for a portable Differential Image Motion Monitor (DIMM) for measuring the transverse coherence length, the isoplanatic angle, and the phase structure function on many research programs, as well as operationally such as at astronomical observatories for turbulent characterization during measurement campaigns. The system should be capable of sensing both stellar sources and of operating over horizontal paths (using laser sources) with up to four pairs of subaperatures with different separation distances. The Atmospheric Turbulence Measurement and Observation System (ATMOS), a system for measuring atmospheric turbulence (Eaton et al., 1988), was developed in the 1980's using custom-designed electronics because nothing was available commercially at that time that would meet the requirements. State-of-the-art sensors and electronics (COTS, when available) must be incorporated into the new system with a wide range of sampling capability (exposure times, frame rates, gains, etc.). Displays and software must be "user friendly" and be easily maintained. A calibration method for the system is required. The telescope used should be of moderate size (14 to 20 inches in diameter) and the tracking should be capable of operating unattended for several hours.

PHASE I: Produce a conceptual design and prototype for the DIMM. Also, produce and demonstrate a detailed analysis of the predicted performance (range of parameters sensed, accuracies, electronics and camera specifications, etc.). Perform preliminary field tests.

PHASE II:Finalize the design and fabricate a DIMM using that design. Produce complete documentation. Extensively field test and evaluate the system under various conditions.

PHASE III DUAL USE APPLICATIONS: Although several DoD programs such as the ABL and ground-based laser programs would greatly benefit with a DIMM using state-of-the-art electronics and sensors, the astronomical community has also shown great interest in such a system. Several measurement campaigns have been conducted at various astronomical sites using unique DoD equipment (Eaton, et al., 1996), and inquiries as to availability, possible costs, etc. of such a system often arise. The ATMOS has been operated at several facilities including Kitt Peak National Observatory, Fred Whipple Observatory, and Apache Point Observatory. A commercially available system would be beneficial, particularly since many major astronomical observatories are now initiating adaptive optics programs.

REFERENCES:

1. Eaton, F. D., W. P. Peterson, J. R. Hines, J. J. Drexler, A. H. Waldie, and D. B. Soules, 1988: Comparison of two techniques for determining atmospheric seeing, Proc. SPIE, Vol. 926, Orlando, Fl., pp 319-334.

2. Eaton, F. D., J. R. Hines, J. J. Drexler, and J. Northrup, 1996: Optical turbulence at Kitt Peak National Observatory, Fred Whipple Observatory, Apache Point Observatory, Horace Mesa, and the Atmospheric Profiler Research Facility, Army Research Laboratory, ARL-TR-1013, 117

KEYWORDS: isoplanatic angle, optical turbulence, site characterization, phase structure function, differential image motion, transverse coherence length

AF99-016 TITLE: Small Inertial Attitude Reference System for Small High-Performance Aircraft Applications

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop a small inertial attitude reference system that will contain a stable mirror to reference optical systems.

DESCRIPTION: This project will design and produce a small and inexpensive inertial attitude system that can be used in an F-16 fighter aircraft as a two-axis optical inertial reference. This type of an instrument may be very useful to a program such as the MEA F-16 aircraft that requires an inertial reference for optical pointing. The system is desired to be small enough that it could be mounted on the secondary mirror of a beam expanding telescope; the goal is to keep the instrument package within a cube 3 inches on a side. The intent of this effort is to conceptualize, design, and produce a prototype unit that is an inexpensive and small inertial attitude reference. An optical surface, such as a small mirror, will be included in the system to provide an inertially stable optical reference. It would be possible to add accelerometers to this unit and obtain a navigation system. However, only the attitude reference will be designed and built under this contract, navigation software will be added by the contractor as s/he deems necessary. The system will be able to operate and measure angular inputs while the telescope is slewing at 1 rad/sec and 2 rad/sec/sec acceleration. It must be able to survive higher rates and accelerations but may saturate. The angular error in the optical reference of this system shall be less than 3 microradians when subjected to the vibration spectrum of a F-16 at 2000-40,000 ft altitude and 0.2 to 2.0 mach number, and less than 1.5 microradians under quiet laboratory operation. Design reviews will cover the components, the system design, and control design concepts for the entire system.

PHASE I: Design the attitude reference system and demonstrate that such a miniature system is within the state of the art. Establish the feasibility of producing the small package and show how this package can be used with a telescope to significantly improve the pointing accuracy.

PHASE II: Develop and demonstrate the components for the two-axis attitude reference system. The instrument shall be demonstrated as a complete system. It is expected that this phase will demonstrate the system operation and include detailed characterization of the control loop performance. If desired, the Air Force will work with the contractor to obtain use of the inertial test equipment at Holloman AFB.

PHASE III DUAL USE APPLICATIONS: It is expected that an ultra small system as conceptualized here would have several commercial and military customers. The military applications will be on all sorts of pointing telescopes for directed laser energy weapons, imaging, and optical communication systems. The commercial use of the system would include navigation systems for land vehicles and possibly aircraft. If the price can be made low enough for the automobile industry, the product would obviously have a huge market. It is expected that the contractor will design a system with many options during Phase I, so that an as-large-as-possible commercial market will be available.

REFERENCES: H. Wrighley and T. Denhard, Gyroscope Theory, Design, and Instrumentation, (MIT Press, Cambridge, MA), 1969.

KEYWORDS: gyroscopes, reference frames, optical pointing, inertial guidance, high g-factor effects, aircraft guidance system

AF99-017 TITLE: Active Remote Sensing Technologies for Chemical Effluent Detection

TECHNOLOGY AREA: Chemical and Biological Defense

OBJECTIVE: Develop component technologies that facilitate meeting performance requirements for active (laser-based) chemical effluent detection.

DESCRIPTION: The growing reality of the threat of chemical attack in both military and civil environments, and the ready availability of chemicals to process deadly toxins and narcotics, indicate a need for suitable chemical detection devices. Remote sensing technologies suitable for counter-drug, counter-terrorism or counter-proliferation applications could provide early warning of a threat in the processing stages of chemicals, or could provide evidence of a suspected release. Chemical effluents may include fuel emissions, industrial by-products of chemical or biological production, as well as toxic chemical agents. Technologies that facilitate longer range detection and quantification of chemical species using active remote sensing devices will be considered for development. Of particular interest are components or systems that improve detection and identification performance of an unknown chemical target, or that improve the operational effectiveness of devices, including compactness, ruggedization and reduced power requirements.

Chemical spectral signatures extend across the entire infrared spectrum, but for detection purposes, the atmospheric transmission windows between 3-5 microns and 8-12 microns provide the greatest potential for detection. Required technologies include:

1. Receivers in this region are susceptible to significant detector noise, and enhancements to receiver detection sensitivity, including noise suppression and signal enhancement, are desirable.

2. Of interest is pulsed laser source technology that shows promise of reaching average powers on the order of >10W in MWIR and 100W in LWIR over all lines in a 1 to 2 micron band, with relatively narrow line width (<0.5 cm-1) and high pulse repetition frequencies (100Hz-10kHz). Also of interest are tuning mechanisms that facilitate tuning over a sequence of >20 lines across the operating band.

3. Automated control of 12 bit, streaming data acquisition at up to GHz bandwidths, real-time signal processing and chemometric analysis algorithms, automated pattern recognition and user-friendly, portable workstations.

PHASE I: Define the system concept and demonstrate key component technological milestones and preliminary design of system or component deliverable. The system approach is meant to ensure that the components developed have utility in meeting the requirements defined above, and can be suitably field tested with existing GFE hardware if necessary.

PHASE II:Complete component design, fabrication and laboratory tests. Define field test objectives and recommended test plan, including required GFE.

PHASE III DUAL USE APPLICATIONS: These lidar systems could be used in both the military and private sectors for counter-drug, counter-terrorism purposes with little or no modification.

REFERENCES:
1. Fox, M. J., N. S. Higdon, D. R. Dean, C. M. Hamilton, D. C. Senft, J. A. Dowling, D. Pierrottet, S. Ghoshroy, and S. B. Alejandro, "CO2 differential absorption lidar (DIAL) research at the Air Force Phillips Laboratory,O International Laser Radar Conference, Berlin, July 1996.
2. Senft, D. C., M. J. Fox, J. D. Gonglewski, J. A. Dowling, R. G. Highland, S. R. Czyzak [1995], "Long path CO2 lidar measurements," Optics in Atmospheric Propagation and Adaptive Systems, SPIE Vol. 2580, 1996.
3. Byer, R. L., and M. Garbuny, "Pollutant detection by absorption using Mie scattering and topographic targets as retroreflectors," Appl. Opt., 12, 1496-1505, 1973.
4. Rothe, K. W., U. Brinkman, and H. Walter, OApplications of tunable dye lasers to air pollution detection: measurements of atmospheric NO2 concentrations by differential absorption, Appl. Phys., 3, 115-119, 1973.
5. Grant, W. B., et al., "Calibrated remote measurement of NO2 using the differential absorption backscatter technique," Appl. Phys. Lett., 24, 550-552, 1974.

KEYWORDS: lidar, gas lasers, chemical sensing, solid state lasers, infrared detection, stand-off detection, chemometric analysis, chemical cloud detection, differential absorption lidar (DIAL)

AF99-018 TITLE: High Efficiency Electric Laser

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop Highly Efficient, Compact, Light Weight, Electrically Driven Lasers for Adjunct Spaced Based Laser (SBL) missions.

DESCRIPTION: The Air Force is currently developing chemical laser systems for use in space. With their energy stored chemically, they are well suited to long-run-time high power applications. The Air Force SBL program has a requirement for lower power lasers that are electrically driven and can be used periodically over an extended time frame. The lasers must be highly efficient at the conversion of electrical power into a diffraction-limited laser beam. These lasers must be compact and light weight. This solicitation is for the development of lasers, laser subsystems, or enabling technologies that improve space based electric lasers. Such technologies include: high-efficiency semiconductor lasers; diode pumped solid state lasers; diode pumped fiber lasers; efficient optical system for coupling semiconductor laser emission into fibers and gain media; novel electrical storage; and innovative thermal management.

PHASE I: Design and model the laser, laser system, or enabling technology, and perform adequate proof-of-principle demonstrations to give confidence for the success of a Phase II program.

PHASE II:Based on initial designs developed in Phase I, develop or fabricate demonstration hardware, conduct in-depth testing, and refine prototype hardware or design.

PHASE III DUAL USE APPLICATIONS: Air Force applications for this technology may have important commercial parallels, such as communications, medical, and materials processing lasers. Military applications include space-based optical information exchange, designation, and illumination. The objective of Phase III is to make the technology developed in the first two phases commercially available for both private-sector and military applications.

REFERENCES:
1. "35-Watt CW Single mode Ytterbium Fiber Laser at 1.1 microns", Muendel M., Engstrom B., Kea D., et. al., Conference on Lasers and Electo-Optics, CPD-28, May 1997.
2. "High-performance Al-free active-region diode lasers", Mawst L.J., Conference on Lasers and Electo-Optics, CMA3, May 1997.

KEYWORDS: fiber lasers, electric lasers, space-based lasers, semiconductor lasers, laser thermal management, space-based electrical storage, diode-pumped solid-state lasers, high efficiency electric lasers

AF99-019 TITLE: Lightweight Ultra-Wideband Antennas

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop new concepts and enhanced capabilities in lightweight wideband microwave antennas for transmitting and receiving.

DESCRIPTION: Lightweight wideband antennas are of interest for a variety of potential applications that range from radar systems on lightweight aircraft, to countermine and unexploded ordnance location, to communications. This technology is of current interest to the Air Force Research Laboratory, Directed Energy Directorate at Kirtland AFB, NM, where research efforts have been underway for a number of years. Wide bandwidth, which can handle a large number of frequencies in the range from 30 MHz to 10 GHz, is of interest for both continuous wave and transient signal transmission. Transient parameters of interest include risetimes in the range of 10-300 pS and pulse widths from a few hundred picoseconds to 5 nS.

PHASE I: Develop and demonstrate innovative applications utilizing ultrawideband microwave technology. Investigate basic feasibility of the proposed applications to determine the specific approaches, identify critical development requirements and potential risks, and provide a basis for determining the potential success of a Phase II effort.

PHASE II:Develop and fabricate a prototype system, conduct laboratory and other tests which will demonstrate a capability with clear commercial potential. Develop commercial partnership interests for a Phase III production and marketing program.

PHASE III DUAL USE APPLICATIONS: The civilian sector has similar requirements for locating buried objects such as pipes or underground cables, and for performing inspections on concrete structures such as bridges or building foundations. Potential uses also include wideband or transient radar on aircraft, and wideband, multi-channel communications for ships, aircraft, and satellites.

REFERENCES:
1. C.E. Baum, L. Carin, and A.P. Stone, eds., "Ultra-Wideband, Short-Pulse Electromagnetics 3, Plenum Press, New York, 1997. 2. E.G. Farr, G.D. Sower, and L.M. Atchley, "Design Considerations for a Half Impulse Radiating Antenna," PL-TR-97-1058, Phillips Laboratory (now Air Force Research Laboratory), Kirtland AFB NM, January 1996.
3. E.G. Farr, C.E. Baum, and W.D. Prather, "Multifunction Impulse Radiating Antennas: Theory and Experiment," Sensor and Simulation Note 413, Air Force Research Laboratory/DE, Kirtland AFB NM, November 1997.

KEYWORDS: antennas, ultra-wideband, transient radar, high power microwave, electronic fields and waves, multi-channel communications

AF99-020 TITLE: Modulated Corner Cube Concept for Laser Communications

TECHNOLOGY AREA: Sensors

OBJECTIVE: Demonstrate a minimum-impact concept for modulation of the light reflected by a corner cube, achieving a modulation rate in excess of 1 Mhz.

DESCRIPTION: Laser communication approaches can meet secure, high-bandwidth communications requirements, but standard laser communication concepts--in which each end of the communications link has a laser source, optical telescope, and acquisition, pointing, and tracking system--are not always appropriate for every potential application. This is particularly true if one end of the communications link is significantly constrained in weight, power consumption, reliability, or cost. However, if an application with these constraints also has low to moderate modulation requirements, an alternate laser communications concept becomes attractive. One example, cited in the following description, is laser communications to and from a very small satellite and the ground; other applications can also be envisioned.

The alternate concept for the small satellite laser communications application is as follows: First, a laser site on the ground illuminates the satellite with a laser having a CW beam. Onboard the satellite is a corner cube, which reflects the incident laser light back to the transmitter on the ground. Associated with the corner cube is a modulation mechanism that reacts rapidly to change the intensity or the polarization of the reflected light (for example, this might be liquid crystal light modulator). By appropriately controlling the modulator, the laser light reflected back to the ground station from the corner cube is modulated with the comm. signal. This approach offers the potential advantage of significantly reducing the size and complexity of hardware required onboard the satellite for laser communications while maintaining the secure communications advantages of laser communications in general.

The feasibility of the modulated corner cube concept for laser communications has been investigated theoretically, and ground- and balloon-based field experiments have been conducted. Ground field experiments were conducted in December 1994, and a high-altitude balloon experiment was conducted in September 1996, using off-the-shelf hardware for a proof-of-principle demonstration. The experiments used 1" corner cubes coupled with a liquid-crystal screen as the modulating element. The tests were 100% successful, with the received signal strength exceeding that predicted before the tests. However, because of the limitations of the liquid crystal screen, the modulation rate was limited to 50 kbps.

The major technology issue in establishing the modulated corner cube concept for many military laser communication applications is the development of the modulation approach to meet the operational requirements for higher modulation rates. To substantially increase the modulation rate beyond that possible with off-the-shelf liquid crystal screens, alternate means of modulation must be investigated and developed.

PHASE I: Conceive and evaluate a range of alternate concepts based on the potential ability to meet operational modulation requirements, technical feasibility, and expected impact on the platform in an operational implementation.

PHASE II: After the Phase I concept evaluation, further develop the most promising concepts (one or two), with the goal of producing proof-of-principle hardware for experimental evaluation and demonstration of performance in the laboratory.

PHASE III DUAL USE APPLICATIONS: The modulated corner cube concept for laser communications is particularly attractive in applications where one end of the communications link is significantly constrained in weight, power consumption, reliability, or cost. By using this concept, low-impact, secure communications links could be established between: 1) ground and very small satellites, 2) manned aircraft and UAVs, 3) satellites and UAVs, 4) satellites or aircraft and unattended ground sensors, and 5) aircraft and ground personnel (special ops, search and rescue operations).
Commercial analogs of these military missions can also be considered. For example, several commercial communication satellite constellations are being launched or are planned for future launches (Iridium, Teledesic, Celestri, etc.). Satellite-to-satellite communication links for these constellations typically use laser communications, but the satellite-to-ground links are always based on RF communication. If high modulation rates can be demonstrated with the modulated corner cube concept, then the larger RF communications package on the satellite could be replaced with a modulated corner cube system, with substantially less impact on the satellite platform.

REFERENCES: C. M. Swenson, C. A. Steed, I. A. De La Rue, and R. Q. Fugate, "Low Power, FLC- Based Retromodulator Communications System," Proceedings SPIE Vol 2990, 1997, pp 296-310.

KEYWORDS: corner cube, optical modulation, laser communications, secure communications, liquid crystal screen, high bandwidth communications

AF99-021 TITLE: Space Capable, Optically Transparent Thin Films

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a space capable thin film with properties that minimize the induction of optical aberrations upon transmission through the film.

DESCRIPTION: AFRL has demonstrated that thin film polymeric membranes are potentially a valid technology for a large concave mirror when used with a real time holographic correction scheme. Pressure is used to create the doubly curved mirror. The membranes on these large apertures will range in thickness from 10 micrometers to 150 micrometers. This technology is very well suited for deploying an optical system to space, since the membranes can be packaged on the ground and erected after deployment. An optically transparent canopy matched with a reflective film will comprise the pressure vessel. This SBIR is focused on the development of an optically transparent canopy. The science and engineering community has done a lot of quality work in the development of optically transparent thin films. The optical performance of these films was primarily judged on its transmissive power characteristics. Since this canopy will be used in an imaging system, both amplitude and phase of the incoming light must be considered in the design space with phase maintenance being clearly the most important aspect. This typically implies that the thickness and the homogeneity of the membrane be held to a very tight tolerance. Specifically, the transmission losses during a single pass should be limited to 5% of the total input power; this total includes both Fresnel losses and absorption. Maximum absorption should be limited to 2% of the total input power. In addition, the wavefront phase error introduced over an aperture of 30 cm during a single pass should be limited to less than 25 nanometers rms. Optical phase testing of these membranes will be completed at the Phillips Site as long as the sample sheets are at least 1 meter in diameter with the area under test being the central 30 centimeters. Phillips will mount the film in a proven test fixture. Test data in the form of interference fringe patterns will be returned to the contractor for evaluation. Two double pass tests will be performed: One will be taken when th thin film is mounted flat, and the other will be pressurized to a curvature with a central deflection to diameter aspect ration of 1:50. Optical losses due to transmission effects shall be accomplished by the contractor. Note that the thickness of the membrane intentionally is not specified and is not considered a crucial design point. This canopy must maintain its optical properties for five years when placed in an environment similar to a geosynchronous orbit around the earth. After five years, transmission losses should still be less than 10% of total input power, and phase error as described above should be maintained below 100 nanometers rms.

PHASE I: Fabricate an optical quality thin film with the goal of achieving the requirements described above. Phase testing will be accomplished by Phillips Site, and transmission characterization shall be completed by the contractor. Complete characterization of the material's mechanical, space survivability and optical properties is required.

PHASE II:Identify the process necessary to scale this thin film to sizes larger than 8 meters in diameter and demonstrate the feasibility of this process by producing, testing and characterizing a smaller film. The techniques used to produce the film should be scaleable to the production of larger films.

PHASE III DUAL USE APPLICATIONS: An optically transparent thin film that preserves both phase and amplitude has many general uses, including: inexpensive optical windows for terrestrial telescope for both home and commercial use; inexpensive windows used by research, testing and manufacturing companies to move beams from a clean room to another location; durable high quality optical beam splitters; substrates for membrane mirrors with curvature; and light shields in space.

REFERENCES:
1. St. Clair, Anne. (NASA, Langley Research Center, Hampton, VA) "Soluble and colorless polyimides". Corporate code: ND210491. Course on High Temperature Polymers, West Point, NY, May 9-11, 1988. Available from AIAA technical library, Journal Annoucement: IAA8914.
2. Authier, B. (CNRS, Laboratoire d'Astronomie Spatiale, Marseille, France) "Thin film solar collectors for material science experiments in space". International Astronautical Congress, 30th, Munich, West Germany.) Sept 17-22, 1979, 10p. Research supported by the European Space Agency.
3. Hecht, Eugene. "Optics" Third Addition, Chapters 5,8,10, 1998. Note: DoD Critical Technology - Cat 16, Budget category 6.1 - Basic research.

KEYWORDS: canopy, thin film, inflatable, space capable, large aperture, membrane optics, optically transparent

AF99-022 TITLE: Room-Temperature Engineerable Nonlinear Optical Materials

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Produce engineerable nonlinear material that operates at room temperature and is sufficiently nonlinear to function at continuous-wave power levels.

DESCRIPTION: Periodic poling of ferroelectric nonlinear crystals has revolutionized nonlinear optics. Combining microlithography with ferroelectric domain reversal has led to engineerable nonlinear optical materials. Periodically poled lithium niobate (PPLN) is available in sufficient lengths and has enough nonlinearity to produce a singly resonant, continuous-wave, optical parametric oscillator with a threshold of less than 5Watts. However, lithium niobate is also photorefractive. The optical fields in the material liberate free carriers. These free carriers eventually migrate out of the optical fields. The displaced carriers create static electric fields which, through the electro-optic effect, generate index changes. These index changes lead to scattering, losses, and phase mismatch of the nonlinear optical process. The index changes can be removed by heating the crystal, which redistributes the displaced carriers and eliminates the static electric fields. Investigators have found the index variations can be reduced significantly by operating the devices at elevated temperatures. Typical operating temperatures for ~10 Watts of infrared pump power are about 180 degrees C. Such elevated temperatures are inconsistent with many AF application requirements.

PHASE I: Demonstrate an engineerable nonlinear optical material that can operate at room temperature. The material will have sufficient nonlinearity for operating singly resonant, continuous-wave, optical parametric oscillators with threshold pump powers in the infrared of less than 5 Watts. The material should have transmission characteristics comparable to or exceeding that of lithium niobate.

PHASE II:Develop manufacturing techniques and technologies to produce this engineerable material for integration into devices.

PHASE III DUAL USE APPLICATIONS: Applications are numerous. Frequency-agile sources could be used in remote sensing and chemical detection, as well as numerous medical applications. AF applications include calibration and bore sighting of infrared systems.

REFERENCES:

1. J. A. Armstrong, N. Bloembergen, J. Ducuing, and P. S. Pershan, ``Interactions between light waves in a nonlinear dielectric," Phys. Rev. 127, 1918-1939 (1962).
2. M. M. Fejer, G. A. Magel, D. H. Jundt, and R. L. Byer, ``Quasi-phase-matched second harmonic generation: Tuning and tolerances," IEEE J. Quantum Electron. 28, 2631-2654 (1992).
3. L. E. Myers, G. D. Miller, R. C. Eckardt, M. M. Fejer, R. L. Byer, and W. R. Bosenberg, ``Quasi-phasematched 1.064- m-pumped optical parametric oscillator in bulk periodically poled LiNbO3," Opt. Lett. 20, 52-54 (1995).
4. W. R. Bosenberg, A. Drobshoff, J. I. Alexander, L. E. Myers, R. L. Byer, "Continuous-wave singly resonant optical parametric oscillator based on periodically poled LiNbO3," Opt. Lett. 21, 713-715 (1996).
5. W. R. Bosenberg, A. Drobshoff, J. I. Alexander, L. E. Myers, R. L. Byer, "93-percent pump depletion, 3.5-W continuous-wave, singly resonant optical parametric oscillator," Opt. Lett. 21, 1336-1339 (1996).

KEYWORDS: quasi-phase matching, nonlinear optical materials, optical parametric oscillation, ferroelectric domain inversion, periodically poled lithium niobate, nonlinear optical frequency conversion

AF99-023 TITLE: High Average Power Modulator for Multi-Gigawatt HPM Sources

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop a prototype modulator capable of driving a vacuum electron beam diode for a repetitively pulsed, multi-gigawatt high power microwave source.

DESCRIPTION: During the last couple of years, the Air Force Research Laboratory and other organizations have been developing High Power Microwave (HPM) sources capable of producing in excess of 1 GW of Rf power, but only on a single-pulse basis. A typical process in the development of a commercial microwave tube by the conventional microwave tube industry is to repetitively pulse the tube, and over several thousand pulses progressively turn up the Rf power and slowly condition the tube. Conventional modulators are incapable of powering any multigigawatt HPM tubes to enable investigating this conditioning process. Hence, an innovative pulsed-power R&D effort is required. The primary emphasis is to use innovative design concepts to minimize the cost and packaging while maintaining the reliability and reproducibility of the output electrical pulse. The electrical considerations must include the ability to apply a maximum 600 kV pulse to a vacuum diode with an arbitrary, but fixed impedance between 10 and 50 Ohms with no more than 5% reflection from the load back to the modulator. The pulse shape must satisfy a 1 microsecond flattop (+/- 5 %) with a 50 nanosecond rise and fall time. Given that this modulator will be used in a repetitive fashion (at up to 100 pulses per second during a 10-second period), cooling issues for the pulse power components and the technique for charging the modulator will be important. Since some experiments using this modulator may not require the full duty cycle, and perhaps only a few pulses, a control system must allow selecting the number of pulses per burst and the pulse repetition rate. The physical size of the modulator should be minimized, and at a maximum should not exceed 25 ft (length) by 10 ft (width) and 10 ft (height), and the weight should be less than 6,000 lbs not counting weight of the insulating medium (such as transformer oil). The interface between the modulator and any HPM tube must be compatible with obtaining a base vacuum of order 2.0E-9 Torr. Given that laboratories exist in various locations (e.g., Albuquerque is at an altitude of 5,300 feet), means that consideration must be given to the possibility that the ambient air pressure is reduced if air insulation of high voltage components is planned. The power supply to energize the modulator is not a deliverable for this project. If transformer oil is chosen as the insulating medium, the oil is not to be delivered with the modulator. The control console for the modulator must be able to be located at least 150 feet from the modulator and provide for interfaces to any high voltage power supply and any laboratory safety interlock systems.

PHASE I: During Phase I of this project the modulator should be designed electrically and mechanically. Consideration will also be given to the source of the prime power, specifically are the power supply requirements consistent with typical laboratory electrical power grids. The mechanical layout must allow for attaching a vacuum system typically used in laboratories for HPM sources, and be consistent with any electrical cross-talk between components and high voltage isolation requirements.

PHASE II:During Phase II a prototype modulator will be built and tested for single shot reproducibility and modest repetitive operation (~ 1 pulse per second for 10 pulses) with tracability to the full burst mode requirement. The main demonstration will be to drive a 10 Ohm, 20 Ohm, and 50 Ohm resistive load and show that the output current pulse tracks the input voltage pulse with minimal inductive loss. The modulator and all documentation will then be delivered to AFRL for installation and final acceptance testing with our HPM sources.

PHASE III DUAL USE APPLICATIONS: Economical, high average power modulators have an amazing potential market for Air Force missions of ACC and AFSOC and civilian markets. Companies and markets already exist for treatment of food and hazardous waste. The major limit for them is the maximum average power available which limits the amount of material that may be processed. Also, there are requirements for economical average power modulators for driving communications systems, modulators for the microwave tubes for the International Linear Collider, Free Electron Laser technology, inter-planetary radio-astronomy, and deep sky radar.

REFERENCES:
1. K. Hendricks, et al, "Extraction of 1 GW of Rf power from an Injection Locked Relativistic Klystron Oscillator", Phys. Rev. Lett., vol. 76(1), p. 154, 1 Jan 1996
2. M. Haworth, et al, "Recent Progress in the Hard-Tube MILO experiment", Proc. SPIE, vol. 3158, July 1997
3. G. Caryotakis, "The Klystron: A Microwave Source of Surprising Range and Endurance", Bull. Of the Amer. Physical Society, vol 42(10), Nov. 1997, p. 1873

KEYWORDS: pulse power, high voltage, average power, pulse modulator, high power microwaves, repetitive pulse modulation

AF99-026 TITLE: Ultra-Narrow Linewidth, Tunable Single-Frequency Ytterbium Laser

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop an ultra-narrow linewidth, single-frequency, TEM00, linearly polarized, low-power (few hundred mW) cw laser, based on trivalent Ytterbium (Yb) in a Yttrium-lithium flouride (YLF) host (1018 nm) as well as in a Yttrium-aluminum-garnet (YAG) host (1030 nm).

DESCRIPTION: Diode-pumping of the trivalent Ytterbium ion has received significant interest because of its efficient lasing operation and high-power scalability. Examples employing a YAG host yield 91% quantum efficiency using a 940-nm pump wavelength with a laser wavelength of 1030 nm. Using a uniaxial host crystal of (YLF), 94.3% quantum efficiency results from using a pi-polarized pump wavelength at 960 nm with an s-polarized lasing wavelength at 1018 nm. Though both hosts are ideally suited for scalable high-power operation, the YLF crystal adds the benefit of low-thermal lensing and negligible birefringence when diffraction-limited operation is desired.

There are many applications that require or could benefit from the use of a scaleable, frequency stable, tunable laser source. A few examples include pump sources for single-frequency optical parametric oscillators (OPO), resonant non-linear frequency conversion, spectroscopy, laser clocks, and remote sensing. Unfortunately, commercially available robust, low-power, single-frequency master oscillator lasers do not exist at the Yb laser emission wavelengths. If available, injection-locking techniques or regenerative amplifiers could be used to scale these low-power sources into high-power, single-frequency, cw laser devices thus increasing the number of possible applications. The YLF host laser wavelength is particularly suited to pumping praseodymium ion in fiber amplifiers for 1.3-um communication systems and to pumping an OPO with intracavity sum-frequency generation (SFG) producing a 589 nm laser for use as a sodium beacon guide star in telescope adaptive-optics systems.

A number of approaches have been used to obtain single-frequency operation in diode-pumped lasers including monolithic non-planar ring oscillators (NPRO), birefringent tuning filters, twisted-mode resonators, and microchip laser designs. In particular, the robustness and frequency stability obtained with the NPRO design for Neodymium:YAG lasers sets a user-friendly standard to strive toward. New, diffusion-bonding processes may make monolithic designs utilizing the Yb ion possible. In addition, though broad-frequency tuning may be achievable, emphasis must first be placed on the laser's free-running frequency stability (better than a few tens of kHz/s for both jitter and thermal drift) for ease of injection locking. Because of the number of applications requiring an ultra-narrow linewidth, it is expected that fast frequency tuning (at least several tens of kHz bandwidth) of the laser device be incorporated for locking to externalREFERENCEs. Examples of externalREFERENCEs might be a high-finesse Fabry-Perot cavity, using the second harmonic tuned to an iodine spectral line, or possibly, if a wide-tunability (up to 1064 nm) is achieved tuning to molecular overtone resonance lines in C2HD, C2H2, or CO2.

PHASE I: Resonator design trade-off analyses are to be conducted, including modeling, to determine the best configuration for ultra-narrow linewidth, tunable single-frequency low-power laser oscillators. Designs should emphasize free-running frequency stability and reliability. The preliminary designs should include both YAG and YLF hosts to determine if similar technology could be used for separate laser systems. Experimental investigations should be conducted to demonstrate the feasibility of the resonator designs at the lasing wavelengths of 1030 nm and 1018 nm.

PHASE II:The proven resonator designs for both YAG and YLF hosts are to progress into more compact, robust packages thus demonstrating their commercial feasibility. This stage will demonstrate the range of the devices' wavelength tunability and their free-running frequency stability. Demonstrate fast frequency tuning and all other aspects of the laser devices. Any other aspect related to the progression to a commercialization phase will be considered at this point in the program.

PHASE III DUAL USE APPLICATIONS: Commercial applications include laser clocks, spectroscopy, creating a sodium beacon guide star for telescope adaptive-optics systems, and a pump source for praseodymium ion in fiber amplifiers for 1.3-um, fiber-laser communication systems. Military applications include illuminators, remote-sensing systems, long-coherence-length lasers, laser clocks, satellite cross-link communications, and creating a sodium beacon guide star for telescope adaptive-optics satellite-tracking systems.

REFERENCES:

1. N. Uehara, K. Ueda, and Y. Kubota, "Spectroscopic measurements of a high-concentration YB3+LIYF4 crystal", Japanese J. of Appl. Physics Part 2-Letters 35, L499-L501 (1996).

2. P. Peterson, M. P. Sharma, and A. Gavrielides, "Modeling of Yb:YAG tuning curves", Opt. Comm. 134, 155-160 (1997).

3. R. Allen and L. Esterowitz, "CW tunable ytterbium YAG laser pumped by titanium sapphire", Electron. Letters 31, 639-641 (1995).

4. T. Y. Fan and J. Ochoa, "Tunable single-frequency Yb:YAG laser with 1-W output power using twisted-mode technique", IEEE Photonics Tech. Letters 7, 1137-1138 (1995).

5. T. Taira, J. Saikawa, T. Kobayashi, and R. L. Byer, "Diode-pumped tunable Yb:YAG miniature lasers at room temperature: modeling and experiment", IEEE J. of Selected Topics in Quantum Electron. 3, 100-104 (1997).

KEYWORDS: MISER, chip laser, ring resonator, ring chip laser, microchip laser, single-frequency, Ytterbium:YAG (Yb:YAG), Ytterbium:YLF (Yb:YLF), traveling-wave resonator, monolithic ring resonator, non-planar ring oscillator (NPRO)

AF99-029 TITLE: Optical Interconnects for Satellite Applications

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop improved components, technologies, or systems for high-speed optical interconnects for space.

DESCRIPTION: Optical interconnects can relieve data bottlenecks that occur between chips, boards, or modules. They have the potential for reducing the latency, excessive weight, and EMI interference found in hardwire systems and increasing computing speed. Due to limitations on capabilities for downlink data rates from satellites, on-board processing is necessary for applications involving large amounts of data, such as imaging and surveillance. On-board computer power is also needed for switching and routing information in communications satellites. This drives the need for high-speed optical interconnects. Microelectromechanical machines (MEMs) or microoptoelectromechanical machines (MOEMs) may be useful as low power switches. The thrust of this topic is to make optical interconnects more readily applicable in space or to improve the performance of interconnects that are already applicable. Improvements might include: decreased power consumption, increased data rates, lower susceptibility to upset due to space radiation, lower weight, and applicability in new systems. Replacement latching and buffering microelectronics which decrease system weight and increase bandwidth performance to a level greater than 100 MB/s, are needed.

PHASE I: Review the existing technology to determine a baseline for the performance of current interconnects. Show that the new concept will increase the performance of potential satellite systems. Identify areas of risk in the interconnect concept and perform theoretical analysis, simulation, and laboratory demonstrations that show that the interconnect can be fabricated and assembled.

PHASE II:Fabricate the interconnect and demonstrate that it increases the capability of a processor or computer that is appropriate for application in satellites.

PHASE III DUAL USE APPLICATIONS: Enhanced processing capability will be useful for controlling switching circuits and for signal processing in military as well as commercial communications satellites. Therefore, the commercialization potential should be high.

REFERENCES:

1. Optical Interconnects in Broadband Switching Architectures (T J Cloonan) SPIE Vol. 2962 244pg/23pp, (Mar 1996).
2. Optoelectronic Interconnects and Packaging IV (R T Chen/P S Guilfoyle) SPIE Vol. 3005, 370pg/39pp, (Apr 1997).
3. Microelectronic Structures and MEMs for Optical Processing III, SPIE Vol. 3226 (Sep 1997).

KEYWORDS: MEMs, MOEMs, optics, interconnect, space applications, radiation tolerant, optical interconnect, optical communications

AF99-030 TITLE: Micro-Latchup Characterization

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop circuit to protect microcircuit from improper operation or burn-up when it enters the state of micro-latchup.

DESCRIPTION: Many commercially available advanced technology CMOS (complimentary metal-oxide semiconductor) and bipolar integrated circuits are latchup susceptible to single event effects caused by heavy ions or protons from cosmic rays or solar flares. This characteristic makes them unsuitable for satellite applications. While the subject of latchup protection has been the object of some previous/current investigations, the subject of micro-latchup has not been addressed. Micro-latchup is a low-level latchup condition that occurs in some types of commercial microcircuits (like microprocessors, digital signal processors and application specific integrated circuit [ASIC] chips). In the micro-latchup case, some small area of the chip enters latchup, which is a condition that prevents its proper operation and can also damage the device. A symptom of this condition is a very slight increase of the supply current into the IC (integrated circuit) device. Putting the device in the standby mode makes this condition more readily detectable. If commercially available IC's are to become space qualified, a low cost, effective process/mechanism must be developed for identifying/rectifying IC's in micro-latchup. The successful remedial circuit must ultimately become an integral part of the IC.

PHASE I: 1) Establish procedure for the detection of very small over currents/micro-latchup conditions, 2) design/fabricate prototype anti micro-latchup circuit, and 3) demonstrate sensitivity, stability and accuracy of the prototype circuit.

PHASE II: 1) Integrate the anti micro-latchup circuit into representative ASIC circuits (to prevent or safely recuperate from micro-latchup), and 2) demonstrate sensitivity, stability and accuracy of the integrated device.

PHASE III DUAL USE APPLICATIONS: Micro-latchup is basically a phenomenon caused by radiation. Commercial applications of the anti micro-latchup circuit lie in IC's used in military/commercial satellites. Commercially available micro-latchup immune IC's would result in significant cost reduction in all space vehicles.

REFERENCES:
1. Horowitz and Hill, The Art of Electronics, Cambridge University Press, 1991.
2. Troutman R., Latchup in CMOS Technology: the Problem and Its Cure, Kluwer Academic Pub, 1986.

KEYWORDS: CMOS, latchup, protons, ASIC chips, bipolar IC, heavy ions, stand-by-mode

AF99-031 TITLE: Thin Film Photovoltaic Blanket for Auxilliary Spacecraft Power

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop space-qualified, large area, thin-film amorphous or polycrystalline semiconductor solar photovoltaic cells integrated on a flexible lightweight polymer substrate.

DESCRIPTION: Thin-film amorphous and polycrystalline semiconductors have been in development for the terrestrial photovoltaic market for over 20 years. Power generation efficiencies of 6-10% are achievable in large area product for ground applications. Only within the last five years has interest grown to apply this technology to the space market. Even though end item efficiencies are lower than conventional single crystal solar cell photovoltaics for space, the primary advantages of thin-film amorphous and polycrystalline photovoltaics are: 1) minimal degradation due to space charge particle radiation environment, 2) potential low fabrication and manufacturing costs, 3) inherent light weight technology, 4) variable circuit design based on thin film fabrication methodology, and 4) flexible substrates can provide light weight structural support. Based on these potential advantages, the object of this project is development of a space qualified thin-film amorphous silicon or polycrystalline semiconductor photovoltaic cell on a light-weight flexible substrate, integrated with a spacecraft thermal blanket. Since a thermal blanket is used to reflect visible and infrared wavelengths, a top layer of a thin-film and flexible photovoltaic on a KAPTON substrate could be implemented to absorb and convert a portion of the visible and infrared energy to power. The purpose of the resulting device is power enhancement, not replacement of the primary power source, to aid in peak power generation for the spacecraft and additional battery charging capability during times of extended payload operations.

PHASE I: 1) Develop a suitable thin-film photovoltaic deposition technique, 2) fabricate a prototype 0.5 ft x 0.5 ft thin-film photovoltaic on a flexible substrate, including applicable circuitry, and 3) demonstrate that the prototype photovoltaic operates at greater than 8% power generation efficiency.

PHASE II:1) Improve cost effective producibility of Phase I prototype photovoltaic and increase power generation efficiency to > 10%, 2) integrate thin-film photovoltaic with flexible thermal blanket, and 3) fabricate (mutually agreed-upon) large area product and demonstrate power efficiency, flexibility, and other attributes of pre-production prototype photovoltaic.

PHASE III DUAL USE APPLICATIONS: A successful, low cost, large area, thin film amorphous or polycrystalline semiconductor photovoltaic cell, mounted on a light weight flexible substrate, displaying at least 10% power generation capability, will have a multitude of terrestrial (swimming pool heaters, domestic hot water heaters, etc.) and space-based (battery charging) auxiliary power applications.

REFERENCES:
1. L. Jiao, Z. Lu and C.R. Wronski, "An Approach to Self- Consistent Analysis of a-Si;H Material and p-i-n Solar Cell Properties," 26th IEEE Photovoltaic Specialists Conference (1997).
2. K. Tabuchi, et al.," Improvement of Large-Area SCAF Structure a-Si Solar Cells with Plastic Film Substrate," 26th IEEE Photovoltaic Specialists Conference (1997).
3. Y. Hishikawa et al., " Optical Confinement and Optical Loss in High-Efficiency a-Si Solar Cells," 26th IEEE Photovoltaic Specialists Conference (1997).
4. A. Slaoui et al., "Polycrystalline Silicon Films Formation on Foreign Substrates by Rapid Thermal-CVD Technique," 26th IEEE Photovoltaic Specialists Conference (1997).

KEYWORDS: solar cells, solar array, auxiliary power, thermal blanket, amorphous silicon, thin-film photovoltaic, polycrystalline semiconductor

AF99-032 TITLE: Satellite Vehicle Tracking via Optical Phase Conjugation

TECHNOLOGY AREA: Sensors

OBJECTIVE: Apply optical phase conjugation principles to satellite vehicle tracking.

DESCRIPTION: Optical Phase Conjugation (OPC) is an optical process whereby wavefronts of light are reversed in phase and direction. One result of OPC is a Phase Conjugate Mirror (PCM) which reflects diverging light so that it converges back to its source point. The PCM is a 3-D mirror which can be created from a solid, liquid, or gas by applying the process of "4 Wave Mixing" to the substance. A satellite vehicle equipped with a PCM could be illuminated by a laser and reflect the laser back with very little amplitude or phase degradation, because the OPC process reverses the effect of atmospheric turbulence. Another OPC-derived capability is an "induced laser," in which a PCM acts as a lasing medium in conjunction with a reflective surface. When the PCM starts lasing, some scattered light reflects off of the reflective surface, creating a self-sustaining laser beam between the PCM and the reflective surface. When the reflective surface is moved, the laser beam moves with the reflector because the beam is optically locked with the reflector. The advantage of a self-locking laser beam to the problem of satellite vehicle tracking is clear--the accuracy and simplicity of satellite vehicle tracking could be enhanced greatly. Since the "induced laser" effect uses an reflective surface, the range of the self-locking effect may be limited due to atmospheric turbulence as well as beam divergence from the reflective surface, and therefore may be suitable only for space-based tracking.

PHASE I: Phase I includes the setup and testing of "4 Wave Mixing" phase conjugate mirrors in the laboratory, with the objective of finding space-qualified mirror material. Continued testing of the phase conjugate mirrors is necessary, with regards to specific constraints (simulated atmospheric turbulence, total mirror reflectivity, reflectivity vs. frequency), in order to develop a database of experimental results. Phase I also includes testing an "induced laser," with the objective of finding the maximum separation distance between the PCM laser and the reflective surface that supports the self-locking laser effect, in order to determine whether an "induced laser" could be used to track satellite vehicles from a ground station.

PHASE II: Phase II includes creating a proof-of-concept demonstration of the "4 Wave Mixing" phase conjugate mirror by installing one on an aircraft and illuminating the aircraft with a low power laser to determine the efficiency of reflection of the mirror in non-laboratory conditions. As part of the same experiment, an "induced laser" reflector would be installed on the aircraft, and a lasing phase conjugate mirror on the ground would attempt to "track" the aircraft at various altitudes and angles.

PHASE III DUAL USE APPLICATIONS: As satellite vehicle density increases, the need for tighter satellite vehicle tracking accuracy is evident. Commercial and military satellite vehicle tracking systems that need to be migrated onto satellite vehicle platforms would benefit from the potentially small size and high accuracy of optical phase conjugate laser tracking. The "induced laser" concept could be applied in the aviation industry as a short range automated landing beacon designed to passively track and guide aircraft down to safe landings.

REFERENCES:
1. Pepper, David M., "Time Reversed Light", Scientific American, Vol 254 No. 1, pp. 74-83, Jan 1986.
2. Zeldovich, Boris, "Optical Phase Conjugation", Scientific American, Vol 253, No. 12, pp. 54-59, Dec 1985.
3. Zeldovich, Boris, "Principles of Phase Conjugation", Springer-Verlag, 1985.

KEYWORDS: wave mixing, "induced laser", adaptive optics, phase conjugate mirror, satellite vehicle tracking, optical phase conjugation (OPC)

AF99-033 TITLE: Developing a Global Ionospheric Assimilation Model

TECHNOLOGY AREA: Battlespace Environments

OBJECTIVE: Develop a global ionospheric assimilation model that correctly incorporates both ground-based and satellite observations from a wide variety of sensors.

DESCRIPTION: This effort seeks to address the specific problem of how to synthesize and incorporate--into currently available, theoretically-based models--the large amounts of ionospheric data that are available from a variety of sensors. This is an attempt to develop a global, assimilative ionospheric model which currently does not exist. If successful, such a model would significantly broaden the applicability and usefulness of ionospheric observations, in general, and would improve the ability to specify and forecast ionospheric parameters globally. The maturity of the global, physically-based, theoretical models to realistically reproduce, in a climotological sense, large-scale ionospheric plasma distributions and features has been well-established by a number of scientists (Preble et al., 1994; Schunk, 1996; Anderson et al., 1997). While the validation and verification of these models has historically been carried out using a limited set of observations over limited geographical regions (low, mid or high latitudes), to date there has been no concerted effort to develop a global, assimilative ionospheric model. The proposed model should incorporate a wide variety of ionospheric observations, meld these appropriately into the model, and produce global distributions of ion and electron density profiles.

There is an ever-growing database of ionospheric observations being obtained from both ground-based and satellite sensors. These sensors include 1) ground-based digital HF ionospheric sounders measuring bottomside electron density profiles, 2) ground-based dual frequency GPS receivers obtaining slant TEC values, 3) ground-based HF radars such as the SuperDarn network in the northern and southern hemispheres measuring ionospheric ExB horizontal drift velocities, 4) two DMSP satellites obtaining in situ electron and ion densities and temperatures at 840 km as well as energetic particle precipitation fluxes and high latitude ExB drift velocities, 5) a GPS/MET low earth orbit (LEO) satellite measuring TEC profiles up to 740 km, 6) a TOPEX dual frequency altimeter on the Poseidon satellite measuring vertical TEC values over the ocean areas, and 7) several EUV satellite sensors (Polar Bear, POLAR, ARGOS) measuring UV radiances from the daytime, nighttime and auroral regions. This work will lay the foundation of how to incorporate the SSUSI and SSULI UV sensor data into ionospheric models.

The availability of this model would immediately serve numerous customers by providing the best ionosphere as a basis to generate tailored products that mitigate impacts on both DoD and civilian operational systems. This is exactly the type of model which is required to move from global ionospheric climotology to global ionospheric "weather". It is appropriate, now, to generate an ionospheric assimilation model because there is an ever-growing database of ionospheric observations from both ground-based and satellite-borne sensors. Additionally, there exists the potential for even greater data sources from the proposed suite of GPS/MET-like satellite sensors, an expanded network of ground-based dual frequency GPS receivers in the International GPS Service for Geodynamics (IGS) network, and the two UV imagers, SSUSI and SSULI, due to fly on DMSP F16 and above.

PHASE I: Develop the preliminary design and concept which describes 1) how the global ionospheric assimilation model will be constructed and how it incorporates a wide variety of observations, 2) what the observations are and what sensors are required, and 3) how the model will be validated once it has been constructed.

PHASE II:Construct a global ionospheric assimilation model, acquire the datasets that demonstrate the accuracy of the model and then validate this accuracy under all conditions according to the validation scheme developed in Phase I.

PHASE III DUAL USE APPLICATIONS: The ionospheric model developed under this program will be useful for many civilian applications. All civilian users (a million plus) of single frequency GPS receivers require realistic ionospheric corrections to achieve accurate navigation position information. This includes all private and commercial aircraft utilizing the future FAA Wide Area Augmentation System (WAAS). The outputs of the assimilation model would provide these corrections. The model also has application as a near real-time, global ionospheric forecast model that could be run at AFSPC's 55 SWXS, who supplies DoD space environmental support, and at the civilian counterpart at NOAA's Space Environment Center. Additionally, the flexibility and computational speed of the model would allow a large number of users the ability to develop ionospheric tailored products for specific navigation and communication customers. It is envisioned that such an ionospheric assimilation model would be the Space Weather equivalent of the National Center for Environmental Prediction (NCEP) Numerical Weather Model which has hundreds of users and applications.

REFERENCES:

1. Preble, Amanda J., David N. Anderson, Bela G. Fejer and Patricia H. Doherty, "Comparisons between calculated and observed F region electron density profiles at Jicamarca, Peru", Radio Science, 29, 857-866, 1994.
2. Schunk, R. W., Solar-Terrestrial Energy Program: Handbook of Ionospheric Models, R. W. Schunk, Ed., August, 1996.
3. Anderson, D. N., M. J. Buonsanto, M. Codrescu, D. Decker, C. G. Fesen, T. J. Fuller-Rowell, B. W. Reinisch, P. G. Richards, R. G. Roble, R. W. Schunk and J. J. Sojka, "Intercomparison of physical models and observations of the ionosphere", Accepted for publication, J. Geophys. Res., 1997.

KEYWORDS: HF radars, space weather, total electron content, electron density profiles, ionospheric assimilation model, ionsopheric specification and forecast

AF99-034 TITLE: Automated Adaptive Task Scheduling for Satellite Network Operations

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop adaptive algorithms and models for automated near optimal task scheduling of satellite network operations.

DESCRIPTION: Satellite network operations can be viewed as a network of satellites and ground stations which require frequent contact links between them for satellite tracking, maintenance, and data dissemination. Contact windows between a satellite and a ground station/satellite are temporal and location dependent. Scheduling of an optimal task sequence for assignment of network resources to meet concurrent contacts (via single beam and/or multiple beam antenna) and other operational requirements without violating temporal, compatibility and capacity constraints, is a complex problem. In addition, constraints, priority, mission requirements, resource availability and emergency requests are dynamic and vary between satellites. Current automated scheduling schemes are incapable of producing near optimal results in real-time for maximum network performance and resource utilization, resulting in costly and inefficient satellite operations. A solution for eliminating this deficiency is to develop adaptive scheduling algorithms capable of achieving optimal tasking order and resource assignment. Cost is then reduced through automation and efficient operations. The purpose of this research is to develop automated task scheduling algorithms that can adapt to changing rules, constraints and scenarios, and which react to provide dynamically updated schedules for satellite network operations. The algorithms would allow for human intervention for approval or override of the schedules generated. At least three algorithms that are intrinsically different in their technical approach should be developed and demonstrated. New and innovative or hybrid techniques with adaptive and learning capabilities should be considered. Potential new resource capabilities and operational concepts such as simultaneous multiple satellite links and distributed scheduling will be factored into algorithm design. Each candidate algorithm will be assessed in terms of the optimality of its scheduling results, computational efficiency, adaptability, response time, generality, testability, extensibility, and degree of human intervention required.

PHASE I: 1) Characterize the scheduling problem for satellite network operations; 2) develop a standard representation of all scheduling parameters, variables, priorities, rules and constraints that are required for input to scheduling algorithms; 3) specify a standard output of scheduling results; 4) formulate candidate adaptive scheduling algorithms which meet requirements as described above for single and/or multiple beam antenna; and 5) demonstrate prototype of each algorithm for a representative limited case.

PHASE II: 1) Construct a representative set of test input scenarios based on hypothetical and AF Satellite Control Network (AFSCN) scheduling requests and contact records; 2) code the candidate algorithms under a single simulated test environment; 3) experiment the algorithm driven by the test scenarios; 4) compare between the performance and efficiency of each candidate scheduling algorithm, the ROSE (Request-Oriented Scheduling Engine) and real AFSCN scheduling results; and 5) identify new technical issues related to the practicality of the candidate scheduling algorithms and additional technology needs.

PHASE III DUAL USE APPLICATIONS: The automated adaptive scheduling algorithms developed from this research are applicable to a wide range of military and commercial systems that require automated near optimal scheduling of service requests and allocating of shared resources in real time.

REFERENCES:

1. Abbott, R. J., Campbell, M. C., Gallini, T. E., Moran, P. J., and Schulenbury D. J., "Automated Scheduling in the Satellite Control Network," Aerospace Report No. TOR-96(1571)-1, 30 January 1996.
2. Ambrose, B. E. and Goodman, R. M., "Neural Networks Applied to Traffic Management in Telephone Network," Proceedings of the IEEE, Vol. 84, No. 10, pp. 1421-1429, October 1966.
3. Cheeseman, P., "Planning and Scheduling in AI," in "Machine Intelligence and Autonomy for Aerospace Systems," Edited by "Heer, E. and Lum H., AIAA, pp. 209-231, 1988.
4. El-Rewini, H., Lewis, T. G. and Ali, H. H., "Tasking Scheduling in Parallel and Distributed Systems," Prentice-Hall, 1994.
5. LORAL Federal Services Corporation, "CCSU Resources Scheduling Study Report," Contract F04701-91-C-108, CDRL A115, Colorado Springs, CO, August 1995.

KEYWORDS: adaptive, heuristics, near optimal, neural network, satellite network operations, automated dynamic scheduling

AF99-035 TITLE: High Bandwidth Photodetectors for Space Applications

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop a high bandwidth photoreceiver for satellite-based optical computing and optical interconnect data links in enhanced environments.

DESCRIPTION: Photoreceivers are among the least radiation-tolerant constituents in optical processors and interconnects. False bit detection, induced by ionizing radiation or the complete failure of receivers, will prevent optical processors or interconnects to be used reliably in space. Current research indicates that 10 GHz receivers are realizable. However, further developments in the design of radiation-tolerant receivers and so-called "Smart Pixels" that can operate as emitter, modulator and detector is required. An example of a promising technology that has an inherently high radiation tolerance through its design, is Fabry-Perot cavity-enhanced Multiple Quantum Well (MQW) structures that also meet anticipated low power requirements.
The photoreceivers should be capable of a bandwidth of 10 GHz or above, and should have a peak detection efficiency at 850 nm for optical processors or the onboard satellite data link, and 1550 nm for inter-satellite communication applications. Potentially suitable, monolithic photodetectors and smart pixels are already under development and may be readily adapted for this application. The final detector design, preferably a III-V detector material monolithically integrated with CMOS, should be capable of operating for a minimum of 10 years in low earth orbit at an inclination of 30 to 60 degrees with a bit error rate of 10(-10). Within this time frame, the detection efficiency should not drop below 50% of the pre-flight performance. If a monolithic design (detector plus driving circuitry) is chosen, both the detector and the driving circuitry is to be radiation tolerant at the above specifications.

PHASE I:Identify a suitable high bandwidth (|10 GHz) photoreceiver or smart pixel design concept. A suitable design has to be advanced to entail the complete growth sheet. The design has to be motivated by modeling the radiation response to ionizing radiation.

PHASE II:Working prototypes of the Phase I design are to be manufactured and evaluated for their speed and suitability for use in space-based application. A feasibility study has to demonstrate that this detector design can be manufactured within practicable costs.

PHASE III DUAL USE APPLICATIONS: Commercial and military space flight missions will rely more heavily on optical interconnects to reduce weight, increase data bandwidth, and reduce the power consumption if radiation-tolerant and reliable solutions have been demonstrated. In particular, laser-based inter-satellite communications will greatly benefit from these detector solutions.

REFERENCES:

1. P.Fay, W.Wohlmuth, C.Caneau, I.Adesida, Electron. Lett. 31, 9, p.755 (1995).
2. R.T. Chen, P.S. Guilfoyle, "Optoelectronic Interconnects and Packaging IV", SPIE Vol. 3005 Feb. 1997.
3. Yao, L., Tanider, J., et. al. "Optical Computing." Applied Optics, Vol. 35, No. 8, 10 March 1996, pp 1177-1179.
4. Yatagai, T., Kawai, S., et. al. "Optical Computing and Interconnects." Proceedings of the IEEE, Vol 84, No 6, Jun 1994, pp 828 - 852.
5. Taghizadeb, M. R., Miller, J. M. , et. al. "Developing Diffractive Optics for Optical Computing." IEEE Micro, Vol 14, No 6, Dec 1994, pp 10-19.

KEYWORDS: space, satellite, smart pixel, photoreceiver, high bandwidth, optoelectronics, radiation tolerant, optical interconnect

AF99-036 TITLE: High Accuracy, Automated Satellite Surveillance Network

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop automated network of Satellite Surveillance Sensors to produce high accuracy angular observations for use with a decentralized orbit determination system.

DESCRIPTION: Satellite operational systems often use control antennae and ranging observations, along with angle observations derived from the gimbal angles of their command, as input to their orbit determination. The range observations can be highly accurate and precise; the angle observations, however, usually lack precision due to their nature as measurements of large, mechanical gears. DoD/NASA/Commercial satellite owners have a myriad of reasons, including collision avoidance, to abate the errors in orbit determination and prediction. The addition of high precision angular observations to the orbit determination process can significantly improve the accuracy of both the orbit determination and subsequent prediction of orbital motion. A network of optical sensors, sharing observations in real time, is needed to provide an efficient and effective method for making high precision observations on satellites and disseminating those observations to orbit determination sites in a timely fashion. In order to obtain high quality orbit solutions from angular observations, the sensors must have a standard deviation of less than 0.5 arc second. The sensor must operate in a completely passive fashion. That is, satellites may not be actively illuminated by laser, nor are the satellites equipped with GPS receivers. The sensor can operate in a variety of climatic conditions, including desert and tropical. The sensor will include automatic weather monitoring equipment. Operation will be remote, with human intervention needed only in the case of hardware failure. Any image processing required to derive the angular observations will be executed in an automatic and timely manner. The sensor will require a minimum amount of infrastructure, and it will be rapidly deployable with total set up and configuration not to exceed 48 hours.

PHASE I: 1) Through cooperation with the Air Force, develop complete familiarity with current needs for high precision observations, 2) develop preliminary design of sensor network complete with documentation that will provide proof of functionality, and 3) produce and demonstrate a prototype to ensure proof of basic design concept.

PHASE II:1) Finalize the design of the sensor network, and 2) build and demonstrate a full-scale operational, prototype network consisting of at least two sensor sites fulfilling mutually agreed-upon Air Force specifications.

PHASE III DUAL USE APPLICATIONS: Development of an automatic sensor network producing high precision observations will spark high DoD/NASA/Commercial demand to increase orbit determination and prediction accuracies. Additionally, technical innovations derived from this effort will have high commercial appeal in the amateur astronomer market.

REFERENCES:
1. Wallace, S., et al., "Use of the Raven Optical Sensor for Deep Space Orbit Determination", Proceedings of the AAS/AIAA Astrodynamics Conference, August, 1997.
2. King-Hele, D., A Tapestry of Orbits, Cambridge University Press, 1992.

KEYWORDS: astrometry, optical sensor, space surveillance, angles-only orbit determination, high precision orbit determination, autonomous satellite ground stations

AF99-037 TITLE: Computer Aided Design (CAD) for Rad-Tolerant, Rad-Hard Microcircuits

TECHNOLOGY AREA: Electronics

OBJECTIVE: Incorporate radiation hardening features into computer-aided semiconductor design tools.

DESCRIPTION: Presently, most semiconductor manufacturers rely on automated design tools to design advanced microelectronics; many also rely on such tools to develop improved semiconductor processes. Most custom semiconductor fabrication facilities expect customers to design their own devices and circuits (or have them designed elsewhere) using design tools; therefore, those facilities are equipped to import these designs. This approach is not presently possible for radiation-hardened microelectronics, since there is no publicly available set of semiconductor design rules that incorporate the features of radiation-hardened electronics. The objective of this project is to develop radiation-hardened design rules capable of being integrated into existing design tool systems or provide radiation-effects models that are compatible with the simulation portion of such tools. The purpose of the radiation-hardened design rules is to facilitate fabrication of radiation-hardened/radiation-tolerant microelectronic devices in commercial fabrication facilities. Developed capabilities will be sufficiently generic that they can be incorporated into a broad range of existing tools and will not rely on a specific manufacturer's design tool system.

PHASE I: 1) Through cooperation with the Air Force, develop complete familiarity with current needs for radiation-hardened design rules. 2) Develop preliminary design of radiation-hardened design rules complete with documentation that will provide proof of functionality and integration capability. 3) Demonstrate mutually agreed-upon key elements of the radiation hardening features that can be incorporated into design tool systems.

PHASE II:1) Finalize design of the radiation-hardened design rules. 2) Demonstrate integration capability of the radiation-hardened design rules into at least two current (mutually agreed-upon) existing design tool systems.

PHASE III DUAL USE APPLICATIONS: This capability would increase the availability of radiation-tolerant electronics and would reduce their cost. This technology would be used by a large number of DoD, as well as other government and commercial space system developers.

REFERENCES:
1. Alexander, David R. et al. "Design Issues for Radiation Tolerant Microcircuits in Space", NSREC Short Course, 1996.
2. Barnard, W. J., Custom High-Reliability Radiation-Hard CMOS-LSI Circuit Design, Sponsor: Department of Energy, Washington DC, Report No. CONF-810533-3, 9p, 1981. (NTIS: SAND-81-0449C).

3. Pease, R. L., "Alexander, D. R., Hardness Assurance for Space System Microelectronics," Radiation Physics and Chemistry, v. 43, n. 1-2 Jan-Feb 1994, p.191-204, 1994.
4. Brothers, C. P. Jr., Chavez, J. R., Radiation Hardening Techniques for Commercially Produced Microelectronics for Space Guidance and Control Applications, Proceedings of the 20th Annual AAS Rocky Mountain Guidance and Contol Conference, Breckenridge, CO, Feb 5-9, 1997 (A97-32906 08-12), Document available from AIAA Technical Library.

KEYWORDS: microcircuits, integrated circuit, radiation-hardened, radiation-tolerant, single-event phenomena, space-qualified electronics

AF99-038 TITLE: Advanced Nonlinear Adaptive Controllers for Fault Tolerant Satellite Trajectory Control

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop an adaptive (neural network or fuzzy logic-based) controller for use with or instead of a conventional controller for satellite maneuvers.

DESCRIPTION: With the current requirements to: 1) increase performance of satellites, 2) guarantee stability, 3) reduce the cost of operations, controller design, synthesis and testing, and 4) to provide for the ability to recover safely from non-catastrophic system failures, it is essential to develop control algorithms and strategies with significant inherent robustness and only nominal dependence on fixed (linear or nonlinear) mathematical models. These algorithms must be developed such that a high level of performance is achievable even with modeling uncertainties, changes in the system dynamics, and common classes of system failures. The issue of implementability based on available hardware must be convincingly addressed. Furthermore, it must be demonstrated that the design, synthesis, and test phase is shorter and less costly than that of conventional methodologies, and that the achievable performance, on-orbit, is better than that of the conventional algorithms.

PHASE I: 1) Develop necessary adaptive control algorithms and generic adaptive satellite controller. 2) Demonstrate the feasibility of using the adaptive controller, desirably neural network or fuzzy logic-based, for advanced satellite maneuvers. 3) Compare the performance of the conventional and adaptive controller on a generic satellite model with known system dynamics. 4) In conjunction with the Air Force, select a specific satellite system (with an imaging system or space-based laser on board) for further development in Phase II.

PHASE II:1) Develop and demonstrate an adaptive controller for the specific satellite system chosen in Phase I. 2) In conjunction with the Air Force, perform an on-orbit flight demonstration on any applicable satellite, perhaps an AFRL MightySat series satellite or a NASA New Millenium Program satellite.

PHASE III DUAL USE APPLICATIONS: Military Application-This approach will be essential to many future military satellite programs because of the high accuracy and high slew rate performance it enables, as well as because of the enhanced survivability that is due to the capability for high levels of performance and stability in the face of non-catastrophic failures. Commercial application-This approach for the design of spacecraft guidance and control systems has tremendous potential because the controller can be applied to large numbers of spacecraft (either of the same type or large classes of different spacecraft), and will have the capability to adapt to a bounded class of variations in the dynamics. In addition, the approach eliminates requirements for a significant amount of on-orbit tuning or trial and error adjustments. This will tremendously reduce cost compared to current approaches.

REFERENCES:
1. Jinwoo, Kim, Zeigler, B. P., "Hierarchical Distributed Genetic Algorithms: A Fuzzy Logic Controller Design Application," Journal: IEEE Expert, vol. 11, no. 3, p.76-84, June 1996.
2. Mitra, Sunanda, Adaptive Fuzzy System for 3-D Vision, In NASA. Johnson Space Center, Proceedings of the Third International Workshop on Neural Networks and Fuzzy Logic, Vol. 2,
p. 309-327 (See N93-22206 08-63), Jan. 1993.
3. Daley, S., Gill, K. F., "The Fuzzy Logic Controller: An Alternative Design Scheme?" Journal: Computers in Industry, vol. 6, no. 1, p. 3-14, Feb. 1985.
4. Daley, S., Gill, K. F., Justification for the Wider Use of Fuzzy Logic Control Algorithms, Proceedings of the Institution of Mechanical Engineers, Part C: Mechanical Engineering Science, v. 199, no. 1, p. 43-49, 1985.
5. Li Wei, Lang, Li, Ma Shuqing, "An Improved Single Adaptive Neural Control Algorithm," Journal of the Harbin Institute of Technology, vol. 29, no. 2, p. 50-53, April 1997.

KEYWORDS: fuzzy logic, neural network, system dynamics, control algorithms, satellite maneuvers, adaptive controller

AF99-039 TITLE: Use of Plastic Encapsulated Microcircuits as Space Qualified Components

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop test procedures and acceptance/rejection criteria for use of Plastic Encapsulated Microcircuits (PEMs) in space.

DESCRIPTION: Although hermetically sealed microcircuits, such as ceramics, have been used successfully in space, there is a potential cost savings if Plastic Encapsulated Microcircuits (PEMs) packaging is used. PEMs are used in packaging over 85% of commercial integrated circuits. Among the possible benefits in using the commercial off the shelf PEM components are: reduced costs/weight, greater availability, decreased size, and access to a commercially developed, enhanced, and on-going improvement process for packaging. On the other hand, while PEMs have been considered for use in space for over a decade, there are some possible obstacles that must be addressed. These include: a) non-hermetic seals, b) outgassing, c) possible degradation due to long-term storage and "non-operating" conditions, d) narrow temperature range, e) package cracking "popcorn effect") during board assembly, and f) not fully characterized radiation hardness. The goal of this project is to develop a test methodology which will qualify PEMs for use in space. PEM parts selected as candidates for space qualification, must conform to existing functional requirements/standards. The project should address various configurations of commercially available PEMs (quad flat packs, ball grid arrays, and other relevant styles). An outcome of this activity (based on actual testing of commercial microelectronic components) would be to build a database from which a set of guidelines may be developed for the use of PEMs in space applications. Test methodology would include statistical quality control methods as well as 100% screen tests and lot conformance tests. The tests must cover a temperature cycling range from -55 degrees C to +125 degrees C, radiation hardness tests covering the range from 100 krad to 1 Mrad, and HAST at 131degrees C for 100 hours. Consultation with existing laboratories which have already begun work in this arena (the PEM community, "PEMC", such as NASA, Rome Lab., commercial companies, the University of Maryland, etc.) as to test procedures and test results required to build consensus and credibility, is strongly advised. Final project results will specify the characteristics for which measurements are needed, the acceptance/rejection range of values, and an estimate of reliability.

PHASE I: 1) Evaluate the relevance to military use of PEMs in space (communicate/coordinate with the PEMC), 2) determine/develop the test parameters/procedures required to be used to satisfactorily/credibly characterize the PEM performance, together with an initial set of acceptance/rejection criteria, 3) test PEMC acceptance of the test plan/criteria and appropriately revise, and 4) define a detailed Phase II test plan together with identification of a set of candidate PEM parts to use in the testing to be done in Phase II.

PHASE II:1) Based on the test procedure framework developed in Phase I, perform tests on the selected parts and characterize their performance, 2) based on the test results, develop acceptance/rejection criteria for use of PEMs in the space environment, and 3) build a database of test procedures/results covering both those which do and do not provide the assessment needed.

PHASE III DUAL USE APPLICATIONS: These procedures would make it possible to use commercial parts in space for both military and commercial applications. With the large number of commercial communications satellites being planned and launched, this project could provide a source of significant cost avoidance.

REFERENCES:
1. Sinnadurai, Nihal, Plastic Packaging Is Highly Reliable, IEEE Transactions on Reliability, Vol. 45, No. 2, 1996 June pp 184-193
2. Al-Sheikhly, Mohamad and Aristou Christou, Tutorial: How Radiation Affects Polymeric Materials, IEEE Transactions on Reliability, Vol. 43, No. 4, 1994 December, pp. 551-556
3. Clark, Steven D. et al., Plastic Packaging and Burn-in Effects on Ionizing Dose Response in CMOS Microcircuits, IEEE Transactions on Nuclear Science, Vol. 42, No. 6, December 1995
4. Emerson, Douglas, Edward Hakim and Anand Govind, Plastic-Encapsulated Microcircuit Reliability & Cost-Effectiveness Study, IEEE Transactions on Reliability, Vol. 45, No. 1, 1996 March, pp. 19-22
5. Ghaffarian, Reza, BGAs for High Reliability Applications, Electronic Packaging and Production, Vol 38, No. 3, 1998 March, pp. 45-52.

KEYWORDS: outgassing, hermeticity, package cracking, radiation hardness, non-destructive inspection, hermetically sealed microcircuits, plastic encapsulated microcircuits (PEMs)

AF99-040 TITLE: Visible Sensor Discrimination Utility and Intersatellite Fusion of Discriminants

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop visible sensor logic for distant object extrapolation and effective discriminant data fusion methods amongst a satellite constellation.

DESCRIPTION: Advanced visible sensing and detection algorithms are applied in such global uses as military and commercial space-based terrain monitoring and event/object identification. Advances in sensor technology have lead to the need for development of visible discrimination fusion algorithms to aide in sensor detection and identification of distant objects and scenarios which may be observed in the visible spectrum. Specifically, development of intersatellite discriminant fusion methods will significantly improve ways in which different satellites view/obtain and fuse information from the same object or signal obtained from different perspectives. The objective of intersatellite discriminant fusion methods is to allow sensors to make sense of the same data from different viewing angles, sides, etc. by fusing the information into a concise picture which provides a more robust object profile/data file by compiling the various observation points. Currently, utilization of Low Earth Orbit (LEO) constellations is growing as communications companies use these constellations as a means of providing near-term improved communications. Future advances in commercial communications, and particularly in sensor applications, will necessitate the fusion of the same data, perceived amongst several satellites in a LEO constellation, from different perspectives. From a military point of view, the need for intersatellite discriminant fusion methods is based on the need to identify a target or re-entry vehicle and to successfully fuse the different aspects of data gathered on these objects to provide a more robust picture as well as a higher level of confidence in identifying the object at hand.

PHASE I: With Air Force assistance: 1) Review current visible sensing/detection algorithms and event/object identification methodology; 2) develop prototype discriminant fusion algorithms/system methodology, designed to resolve multiple perceptions of the same image; 3) identify/develop simulated visible signatures (events/objects) which can be used to test discriminant fusion algorithms; and 4) demonstrate (mutually agreed-upon) key elements of the discriminant fusion system methodology.

PHASE II:1) Finalize development of the discriminant fusion algorithms and system methodology, and 2) provide proof-of-concept demonstration of discriminant fusion system methodology (to Air Force and contractor mutually agreed-upon specifications and operational environment).

PHASE III DUAL USE APPLICATIONS: Several computer, telephone, and other communications companies are developing LEO constellations to enhance communications capability in the near future. The eventual need for these companies to resolve objects and/or information gathered from the various positions of several LEO satellites will require the resolution and integration capabilities of the algorithms/methodology developed in this project.

REFERENCES:

1. Donald J. Dichmann, "The Constellations in LEO", Launchspace, pg 40-42, August/September 1997.
2. Adam Kleiner, "The Assembly Line", Launchspace, pg 42, August/September 1997.
3. Iyengar, S. S., Jones, B. J., Wavelet-Based Fault-Tolerant Integration and Target Recognition in Multidimensional Sensor Signal Processing, This product may be ordered from NTIS by phone at (703) 487-4650; by FAX at (703)321-8547; and by E-Mail at 'orders ntis.fedworld.gov.'
4. Anderson, J. C., Downs, G. S., et al., Signal Processor for Space-based Visible Sensing, Proceedings of SPIE - The International Society for Optical Engineering v. 1479. Published by International Society for Optical Engineering, Bellingham, WA, p.78-92, 1991.
5. Eversmeyer, K. E., Watts, W. D., Bube, E., A Schema for Fusion of Simultaneous Measurements of LWIR and Visible Signature Data, In: Signal processing, sensor fusion, and target recognition II, Proceedings of the Meeting , Orlando, FL, Apr. 12-14, 1993 (A94-29761 09-63). (SPIE Proceedings vol. 1955), p. 117-131, 1993.

KEYWORDS: midcourse tracking, optical algorithms, algorithm development, space-based visible sensing, space-based terrain monitoring, space-based object discrimination

AF99-041 TITLE: New, Innovative Battery Charge Control System

TECHNOLOGY AREA: Electronics

OBJECTIVE: Extend life of solar-charged space batteries by optimizing the charging system.

DESCRIPTION: Orbiting satellites require a constant power source to operate effectively. While in direct sunlight, satellites are able to harvest the sun's energy via solar cells. However, when the satellite is in the Earth's shadow, there is no direct sunlight, and the satellite has to rely on internal energy to continue its mission. This internal energy is provided by secondary electrochemical batteries. Secondary batteries store the surplus energy generated by spacecraft solar arrays. Since each type of battery's life span can be optimized by following a precise charging pattern, there is a continuing need to improve the battery charging profile. Proposals relating to optimized charging profile of existing batteries and/or proposals relating to new battery technology and associated optimum charging strategy are solicited.

PHASE I: Utilizing Air Force input, identify future power requirements and power consumption profiles for a specific communications satellite-related mission. Identify one or two battery types that are most likely to be used in the mission. Based on the power consumption profile, and the cyclic current generation characteristics of the solar array over the course of the orbit, explore battery configurations and charging strategy to maximize the useful life of the satellite. Design/develop a prototype optimum battery charging system. Provide breadboard demonstration of life expectancy resulting from optimized battery/battery charging profile.

PHASE II:Finalize design/construct an optimized battery/battery charging system which provides an optimal system level solution to the cyclic current generating characteristics of solar arrays and the optimum charging requirements of satellite batteries. Assess the "quality" of power and the reliability of the final product in a simulated "space environment" demonstration of the optimized battery/charging system.

PHASE III DUAL USE APPLICATIONS: Commercial and military satellite operational life will benefit from successful research and development in this area. Optimized battery charging strategies (which extend battery life and operation) are applicable to a myriad of battery operated equipment.

REFERENCES:
1. R. Graf, The Modern Power Supply and Battery Charger Circuit Encyclopedia, McGraw Hill, 1992.
2. P. Horowitz and W. Hill, The Art of Electronics, Cambridge University Press, 1989.

KEYWORDS: solar arrays, constant power, satellite battery, battery charging profile, power consumption profile, secondary electrochemical battery

AF99-042 TITLE: Magnetic Device Design for High Temperature, High Performance Applications

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop new high temperature magnetic device performance models based upon device excitation/thermal conditions.

DESCRIPTION: The design of high frequency, high performance magnetic components for the next generation power systems depends upon accurate modeling of magnetic core losses and other operational parameters as a function of thermal/electrical environment. For instance, the use of high temperature silicon carbide transistor switching devices will significantly impact the design of ferrite core magnetic components of the switch. Historically, magnetic device design has been based upon vendor-published performance data and empirically determined thermal design guidelines. As operating temperature, packaging densities and thermal management techniques change, these traditional sources of design information are no longer adequate. A pervasive need exists to develop design criteria and performance models for advanced, high performance, magnetic component-centered devices based upon accurate material characterization and integrated thermal/electrical design data. One approach to the problem (among others) would be to develop test procedures (and associated test equipment) to evaluate magnetic material/component performance as a function of excitation conditions resulting from frequency variation, waveform configuration, duty cycle, environmental/operating temperature, thermal management strategies, wire winding/interconnection configurations, etc. Based upon the inputs that will result from the test procedures previously developed, construct a model/simulation program capable of generating the desired design data. This model would then be validated utilizing test results/data from a test program structured on the test procedures previously generated. Typical design data include (among others) frequency/power-dependent hysteresis curves and transfer functions based upon the magnetic material and upon selected power system related magnetic component configurations (designed and/or acquired from several component suppliers). Magnetic component test configurations shall utilize several different materials and construction techniques. Frequency ranges of up to 5 MHz, power levels of one KW and greater at 70-120 Volts primary, together with 3X transients up to 360 Volts and temperature ranges up to the Curie Point of the material being tested, are to be considered.

PHASE I: Activity shall include: 1) select/design detailed test procedures/test equipment required to evaluate magnetic component performance, 2) develop detailed flow chart/preliminary design of model/simulation program capable of generating desired design data, 3) complete draft of design model and provide demonstration of basic model capability, 4) develop detailed Phase II test plan to generate test data and validate design/simulation model, and 5) design/select magnetic component test configurations.

PHASE II:1) Acquire/design and construct test equipment, acquire magnetic test components and perform test plan, 2) finalize simulation model and perform validation tests of design model utilizing data acquired from test plan, 3) modify design/simulation model, if required, and 4) document design parameters over range of conditions investigated within test plan.

PHASE III DUAL USE APPLICATIONS: Successful development of a design/simulation model and publication of design parameters for power system-related, high temperature magnetic components will be of high interest/demand to both DoD and commercial electrical equipment manufacturers.

REFERENCES:
1. J.J. Rousseau, et. al., A Complete Hysteresis Model for Soft Ferrites Taking Into Account the Temperature, 1996 IEEE PESC proceedings pp 322-328.
2. F. Tan, et. al., A Practical Approach for Magnetic Core-Loss Characterization, IEEE APEC proceedings, pp 572-578.

KEYWORDS: power systems, packaging density, performance/simulation models, thermal/electrical environment, high temperature transister switch, high temperature magnetic components

AF99-043 TITLE: Development of a Laser-Based Single Event Effect Probe Station

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop a compact laser-based single event effect probe station for use in microelectronic design and test.

DESCRIPTION: Laser-based testing of microelectronic components for susceptibility to single event effects (SEE) is a viable alternative to particle-beam testing for screening of parts as an element of the hardness assurance process. However, laser-based testing to date has been confined to utilization of expensive optical table-top systems and has been primarily employed for research. This proposal envisions the development of a diode laser-based SEE probe station which could be used by the microelectronic designer and test engineer. The probe station would be compact and would ideally be designed to facilitate wafer-probe evaluation of parts, a task which is impractical with current systems. The probe station shall be constructed to hold a solid state laser or other compact and vibration insensitive lasers and shall focus the laser beam onto the device under test (DUT). The microscope setup would be mounted on a two-dimensional translation stage with sub-micron spatial resolution that would move the diode laser, focusing optics, and associated apparatus through at least one inch of travel in orthogonal directions in the plane of the DUT. Ideally, the probe station would be modular so that various lasers could be used as needed to take advantage of different laser wavelengths. Simulation of single event phenomena will require laser pulses shorter than 50 psec in duration. The exact pulsewidth required is unknown; however, typical research facilities use pulses of 20 psec or less. Lasers with wavelengths in both the 600-650 nm and 800-900 nm ranges are desirable. Pulse energies should exceed 0.1 nJ. Pulse repetition rates should range from single shot to a few hundred hertz. The microscope would contain a zoom lens device in order to focus and control the laser spot size in the plane of the DUT. Spot sizes from 200 microns down to 1-2 microns would be desirable. This spot size requirement assumes a Gaussian shaped pulse with the designated spot sizes at the 1/e diameter of the intensity. The microscope system would also contain two additional ports: one to allow injection of white light to illuminate the region under test, and the other to allow imaging of the device under test using a CCD (charge coupled diode) camera system. The microscope-laser assembly should be compact and designed to be integrated with a standard microelectronics wafer probe station.

PHASE I: Perform the layout and design of the SEE test module. This would include:
1) mechanical layout and design; 2) optical CAD, including optical propagation analysis to ensure small laser spot size on the sample as well as the integration of the white light source and imaging system; and 3) analysis of the interface requirements to integrate the laser assembly into a standard microelectronic test station.

PHASE II:1) Develop a prototype of the laser SEE test module and demonstrate its integration into a standard microelectronic probe station. 2) Perform tests on standard devices (e. g., SRAMs) to validate the system performance.

PHASE III DUAL USE APPLICATIONS: The system would benefit design and test engineers in the defense industry as well as those in commercial industries who are concerned about SEE and want to incorporate SEE test results into the design process at an early stage. SEE affects microelectronics for avionics as well as spacecraft. SEE are also of concern to designers of memory devices such as SRAMs (static random access memory) and DRAMs (dynamic random access memory), which may be susceptible to soft errors induced by radioactive decay in the natural terrestrial environment or by cosmic rays. The SEE test system would also have potential applications for testing charge-coupled device imaging sensors, as well as other imaging sensors, by allowing charge to be generated within a single pixel or within multiple pixels. This would be of use for evaluating fill factor or charge transfer efficiency in devices used as star trackers, or in medical, dental, and other imaging applications. There are also other potential medical applications, such as scanning of the cornea to determine its curvature, or scanning portions of the retina to examine the localized health of the rods and cones.

REFERENCES:
1. Q. Kim, H. R. Schwartz, L. D. Edmonds, and J. A. Zoutendyk, "Diagnosis of NMOS DRAM Functional Performance as Affected by a Picosecond Dye Laser," Solid State Electronics, vol. 35, pp. 905-912, July 1992.

2. A. H. Johnston, "Charge Generation and Collection in p-n Junctions Excited with Pulsed Infrared Lasers," IEEE Trans. Nucl. Sc., vol. NS-41, December 1994.
3. J. S. Mellinger, S. Buchner, D. McMorrow, W. J. Stapor, T. R. Weatherford, and A. B. Campbell, "Critical Evaluation of the Pulsed Laser Method for Single Event Effects Testing and Fundamental Studies," IEEE Trans. Nucl. Sc., vol. NS-41, pp. 2574-2584, December 1994.
4. "Correlation of Picosecond Laser-Induced Latchup and Energetic Particle-Induced Latchup in CMOS Test Structures," Steven C. Moss, Stephen D. LaLumondiere, John R. Scarpulla, Kenneth P. MacWilliams, William R. Crain, and Rocky Koga, IEEE Trans. Nuclear Science NS-42, 1948-1956 (1995).

KEYWORDS: microelectronics, radiation effects, hardness assurance, single event effects, laser based SEE probe, particle beam testing, microelectronics wafer probe

AF99-044 TITLE: Methods to Characterize and Qualify Thick-Film SOI Wafers

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop methods to characterize and qualify thick-film SOI starting material.

DESCRIPTION: Thick-film (greater than 1 micrometer) Silicon-On-Insulator (SOI) wafers are now being used to manufacture a variety of electronic products with advanced features, such as analog integrated circuits that have improved accuracy, digital integrated circuits that operate at higher frequency and lower power, high voltage devices that are monolithically integrated with signal processors, and micromachined sensors that offer higher precision, increased reliability, reduced size/weight, and lower cost. One of the problems encountered in manufacturing these SOI products, however, is that many of the metrology techniques and instruments needed to characterize and qualify the SOI starting wafers are lacking. Technology/processes/equipment are urgently needed to verify/characterize such basic properties as: 1) the thickness of the silicon film and the buried insulating layer (these values cannot generally be measured quickly and accurately, especially for silicon films thicker than about 10 micrometers); 2) the integrity of the silicon film to insulating layer bond interface (at which microvoids and contamination are both important and difficult to measure); 3) the resistivity and defect density of the silicon film; 4) the density and charge trapping properties of the buried oxide; and 5) the presence and concentration of contaminants, such as oxygen, carbon, and heavy metals. Because of the way bonded wafers are now manufactured, a cassette of finished wafers may contain material from different silicon crystals, and these wafers may have been oxidized, bonded, ground, and polished at different times, or even using different pieces of equipment. This precludes the use of lot sampling methods to qualify the material, making it imperative that the characterization tests that are proposed be cost effective, possess timely on-line capability, and be non-destructive. Examples of non-destructive test methods include, but should not be limited to, optical, x-ray, acoustical, and non-contact-electrical.

PHASE I: 1) Define and evaluate one or more of the measurement techniques identified in the topic Description (above); 2) based on the evaluation data, select one, or more, techniques and identify/develop required technology/processes/equipment to the extent that will allow a demonstration of key elements of the measurement technology; and 3) provide a demonstration of key elements of the selected technology(s) to provide confidence in the success of the Phase II effort.

PHASE II:1) Finalize the measurement technology(s) demonstrated in Phase I, 2) design/procure/fabricate required production prototype equipment, 3) accurately define and implement process parameters/ procedures/documentation of results and finalize any required software, and 4) provide a statistically valid demonstration of the validity of the selected measurement technology(s).

PHASE III DUAL USE APPLICATIONS: Commercial products based on thick-film SOI are now in early production. Many of these products are of high interest to DoD/commercial arenas, as is evidenced by the recent invocation of Title III of the Defense Production Act to ensure an on-shore thick-film SOI supplier. Thus, the market for the proposed characterization system would include the thick-film SOI wafer manufacturers, commercial users of these wafers, and the government.

REFERENCES:
1. Specifications for Thick Bonded SOI Wafers, SEMI Document No. 2540 (Draft), Semiconductor Equipment and Materials International, 805 East Middlefield Road, Mountain View, CA 94043, Attn: Kate Dettenrieder at (415) 940-7997.
2. W. P. Maszara, "Silicon-On-Insulator by Wafer Bonding: A Review," J. Electrochem. Soc., Vol. 138, No. 1, p. 341-347, January 1991.
3. Proceedings of the Annual IEEE International SOI Conferences, and the several International Silicon-On-Insulator Technology and Devices Symposia and International Semiconductor Wafer Bonding: Science, Technology, and Applications Symposia, which are sponsored by the Electrochemical Society.

KEYWORDS: bonded wafers, semiconductors, integrated circuits, silicon-on-insulator, dielectric isolation, micromachined sensors

AF99-045 TITLE: Digital Signal Processing Circuit with Embedded Reprogrammable Nonvolatile Memory

TECHNOLOGY AREA: Electronics

OBJECTIVE: Integrate digital signal processing circuits with reprogrammable non-volatile memory to achieve field reprogramming capability.

DESCRIPTION: Digital signal processing (DSP) circuits are often used in advanced communication systems for noise suppression and signal extraction. The functionality of a DSP circuit is customized and tailored by software to suit the task. The codes are normally stored in electronic memory. Read-only memories (ROMs) are preferred because they are non-volatile. However, the use of ROMs makes it difficult to reprogram the functionality of the circuit. Embedding reprogrammable nonvolatile memory integrated with a high performance DSP circuit, fabricated with Silicon-On-Insulator (SOI) complimentary metal-oxide semiconductor (CMOS) technology, would eliminate the need for ROM, and support reprogramming in the field. The reprogrammable nonvolatile memory could retain data indefinitely without power being applied, and would, ideally, have the additional advantage of being radiation hard. A potentially lucrative, commercial need exists to develop cost effective methodology to inject reprogrammable nonvolatile technology into DSP circuits. The added flexibility of field reprogrammability would extend future mission capability of a myriad of military and commercial systems.

PHASE I: 1) Investigate design architecture trade-offs and process integration issues concerned with embedding reprogrammable nonvolatile memory in DSP circuits, 2) develop preliminary design for reprogrammable nonvolatile memory embedded DSP circuits, 3) develop prototype fabrication process for production of reprogrammable nonvolatile memory embedded DSP circuits, and 4) fabricate and demonstrate basic circuit.

PHASE II:1) Finalize basic design of DSP circuits with embedded reprogrammable nonvolatile memory, 2) finalize production process, and 3) fabricate and test (mutually agreed-upon) reprogrammable nonvolatile memory embedded DSP circuits.

PHASE III DUAL USE APPLICATIONS: DSP circuits are commonly used in a number of military and consumer applications, such as video and audio communication, image processing, radar, sonar signal processing, or graphics and scientific data analysis. Having the option of reprogrammability would render the circuit "smarter and friendlier" and would enable development of new applications in multiple areas, such as artificial intelligence, virtual reality, robotics, and all types of control systems, to name only a few.

REFERENCES:

1. J. M. Daughton, Ferroelectrics, 116, 1175 (1991).
2. A. V. Pohm, R. S. Beech, J. M. Aughton, E. Y. Chen, M. Durlam, K. Norquist, T. Zhu, and S. Tehrani, J. Appl. Phys. 79, 5889 (1996).
3. G. B. Granley and A. T. Hurst, Proceedings of the Sixth IEEE International Non-Volatile Memory Technology Conference in Albuquerque, 138, June, 1996, Publication 96TH8200.

KEYWORDS: radiation hard, non-volatile memory, field reprogrammability, read only memories (ROMs), digital signal processing (DSP), magnetoresistive random access memory (MRAM)

AF99-046 TITLE: Solid-State Power Amplifier Modules for Wideband (L-Ku) Array Antennas

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop wide-band microwave solid-state power amplifier modules that demonstrate highly efficient performance in multicarrier applications for spaceborne phased array transmit antennas.

DESCRIPTION: This project addresses a common, space-related, DoD/commercial need: namely, to develop a method/device to simultaneously handle several carriers--in solid-state power amplifier chains widely separated in frequency--while reducing the intermodulation products to acceptable levels. A stepwise approach (among others) is envisioned. Initially, microwave integrated circuit (MIC) structured discrete devices will be used to demonstrate how to achieve the required performance; the design will then be transitioned to microwave monolithic integrated circuit (MMIC) technology to show compatibility with the current modules being considered for phased arrays. The power output of the test modules should be between two and three watts with a quiescent power of approximately ten milliwatts. The future application for these devices will be for military satellites as well as commercial satellites operating in X-band. Since multiple modulated carriers will be applied to the modules, the reduction of intermodulation products is one of the key issues. Potential voltage peaks that could cause device degradation as a consequence of beat frequencies is one of the reliability issues. Compensation techniques will be required to meet performance goals. The compensation techniques to be considered include, but are not limited to, the following: 1) automatic gain and level control to maximize efficiency with minimum intermodulation products, 2) a predistortion network to improve linearity and phase matching, 3) wideband characteristics to enhance phase matching, and 4) temperature compensation circuits.

PHASE I: 1) With the concurrence/assistance of the government sponsor, review/specify the requirements that meet the potential uses in both military and commercial communication systems, 2) determine/design/model approaches to meet the identified requirements, and 3) demonstrate mutually agreed-to key elements of the selected design to provide proof-of-design concept.

PHASE II:1) Fabricate hardware and perform adequate testing to demonstrate that significant improvement has been achieved in amplifier performance with regard to efficiency, linearity, phase matching, temperature stability, and reliability through the use of compensating circuitry. 2) The concept should be demonstrated first in MIC structures, and then transitioned to MMIC technology in order to show compatibility with current module developments.

PHASE III DUAL USE APPLICATIONS: Phased arrays are receiving considerable attention in both the military and commercial space communications and radar communities. Accordingly, the effort proposed is directly applicable to many systems under serious consideration for future deployment that involve multiple carrier transmission and in which the reduction of intermodulation products is a key requirement.

REFERENCES:
1. R. Yarborough, D. Heston, P. Saunier, H. Q. Tserng, K. Salzman, and R. Smith, "Four Watt, Kt-Band MMIC Amplifier," IEEE MTT-S Digest, 1994.
2. K. Yamauchi, K. Mori, M. Nakayama, Y. Mitsui, and T. Takagi, "A Microwave Miniaturized Linearizer Using A Parallel Diode," IEEE MTT-S Digest, 1997.
3. L. Rowe, C. Chen, M. Harley, J. Lester, S. Huynh, J. Chi, J. Choe, L. Ma, S. Pratoner, C. Wright, A. Ho, R. Lai, K. Brown, R. Duprey, W. Jones, and D. Chow, "Active Aperture Downlinks," Milcom Conference Record, 1995.
4. R. J. Mailloux, "Phased Array Antenna Handbook," Artech House, 1994.
KEYWORDS: linearity, phase matching, beat frequencies, wideband characteristics, intermodulation products, multiple modulated carrier, microwave solid-state power amplifier, microwave monolithic integrated circuits

AF99-047 TITLE: Integrated Bilateral Electronic Components Technology for Spaceworthy Multi-Chip Modules

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop techniques to allow bilateral, passive components (resistors, capacitors, inductors, transformers) to be integrated in the multi-chip module fabrication process.

DESCRIPTION: Passive electrical components are a part of every electronics assembly. Significant success has been achieved in massive integration of active components (e.g., transistors, diodes) into integrated circuits. Passive components, however, are more than often attached discretely to the next level of assembly, whether a hybrid, multi-chip module (MCM) or printed wiring board. Specialized, low-profile resistor and capacitor components have been traditionally employed in hybrids and MCMs. However, these components and the labor associated with inserting them into an MCM is significant. Even in highly automated assembly operations, the expense of inserting passive components is greater than that of the components themselves. This problem will be exacerbated as more designs migrate from discrete analog and mixed signal assemblies to MCM form. By incorporating the components into the MCM fabrication process directly, the expense of procuring, screening, and assembling dozens of components is practically eliminated. Furthermore, integral components will provide for a greater overall substrate efficiency, resulting in smaller, more efficient, and more reliable MCMs. The net benefit to military/commercial space systems is a reduction in size, weight, power, and cost, with a collateral benefit in improved performance, particularly in mixed signal systems which often require complex networks of these components. The objective of this project is to develop innovative technologies to allow integration of bilateral, passive components in the MCM fabrication process. The preferred technique is one which will allow formation/integration of these components within the interconnection system itself and will be applicable and transferable to high performance polymeric-based MCM technologies. Alternately, but less desirable, are approaches that depend on a particular type of substrate. Of least interest (but an acceptable approach) is the development of a new, unique MCM technology. Component electrical quality is of primary concern, as is the ability to closely and repeatably form these components to a degree of precision adequate for analog instrumentation and signal processing applications.

PHASE I: 1) Through cooperation with the Air Force, develop complete familiarity with current needs for integration of bilateral, passive components in MCM modules, 2) develop preliminary design of integration technique, complete with documentation that will provide proof of functionality, and 3) produce and demonstrate a prototype to ensure proof of basic integration concept.

PHASE II:1) Finalize integration technique design, 2) build a full-scale operational, prototype integration process facility, and 3) produce/demonstrate prototype MCM modules containing integral passive components to agreed-upon Air Force specifications.

PHASE III DUAL USE APPLICATIONS: The results of a successful Phase II approach would lead to a superior integrated passive circuit technology that could be transferred to a number of candidate MCM approaches that will spark high DoD/NASA/Commercial desire to achieve reduction in size, weight, power, and cost, with a collateral benefit in improved performance for space-based applications.

REFERENCES:

1. Reamy, Philip C. Incorporating Digital and Analog Integrated Circuit Die on a Common Substrate Utilizing Silicon-Hybrid Wafer-Scale Integration Technology. MS thesis, Air Force Institute of Technology (AFIT/GE/ENG/92M-07), Wright-Patterson AFB, OH, March 1992.
2. Seraphim, D. P. et al. Principles of Electronic Packaging. McGraw-Hill, Inc. 1989.
3. Presentation Material from "Electronic Packaging and Interconnect Program Review", sponsored by DARPA/ETO, Hyatt Regency, Reston VA. Refer inquiries to DARPA/ETO, 3701 N. Fairfax Drive, Arlington, VA 22203-1714.
4. Low, Y. L., Frye, R. C., The Impact of Miniaturization and Passive Component Integration in Emerging MCM Applications, Proceedings of 1997 IEEE Multi-Chip Module Conference, 4-5 Feb 1997, Santa Cruz, CA, p. 27-32.
5. Frye, R. C., "Passive Components in Electronic Applications Requirements and Prospects for Integration," SPIE 1996 International Conference on Multichip Modules 17-19 April 1996, Denver, CO; International Journal of Microcircuits and Electronic Packaging , vol. 19, no. 4, p. 483-490, 1996.

KEYWORDS: resistors, capacitors, multi-chip modules, integrated circuits, electronics packaging, mixed-signal technology

AF99-048 TITLE: SEU-Tolerant Low-Voltage CMOS Technology

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop a technique for ensuring the single-event upset hardness of low-voltage CMOS technology.

DESCRIPTION: The use of CMOS (complimentary metal oxide semiconductor) technologies at voltages at or below 1V would allow substantial reductions in power requirements for space systems. Currently space systems operate at 5V or higher, with a trend to 3.3V. Reducing operating voltages below 1V would dramatically reduce the power system weight and size, and would lead to the early development and deployment of microsatellite systems. However, reduced supply voltages are usually accompanied by an undesirable reduction in speed performance, radiation tolerance, and noise margin. In particular, single event hardness degrades substantially as the supply voltage is lowered, because the reduced total charge stored at floating nodes is more easily upset. This investigation would define a framework for utilizing CMOS technologies to operate at voltages below 1V without sacrificing SEU (single event upset) hardness.

PHASE I: Develop and demonstrate a circuit architecture, targeted to one or more specific CMOS processes, that will exhibit a single event upset rate less than 1 x 10(-8) error per bit per day or 1 x 10(-8) error per gate per day in the Adams 90% worst-case environment, when operated at or below 1V.

PHASE II:Design/construct a sample circuit such as a SRAM (static random access memory), a latched shift register, or a microprocessor, utilizing the architecture and technology developed in Phase I. Demonstrate that the circuit's single event upset tolerance meets the requirements defined in Phase I when operated at or below 1V.

PHASE III DUAL USE APPLICATIONS: The development of an SEU tolerant low-voltage CMOS technology would benefit both military and commercial satellite systems. In addition, the results of this effort may also be applied to improving single event upset hardness in advanced ground-based commercial products due to susceptibility to cosmic particles and radioactive contaminants.

REFERENCES:

1. R. Gonzalez et al, "Supply and Threshold Voltage Scaling for Low Power CMOS," IEEE J. Solid-State Circuits, 32, 1210 (1997).
2. J.B. Burr, "Cryogenic Ultra Low Power CMOS," in IEEE Int. Symp. Low Power Electronics, 1995, p. 94.

KEYWORDS: low-voltage, noise margin, space systems, speed performance, radiation tolerant, SEU (single event upset)-tolerant, CMOS (complementary metal oxide semiconductor) technology

AF99-049 TITLE: Hardened VHSIC Hardware Description Language Digital Signal Processing Module Generator

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Enable designers of hardened DSP Application Specific Integrated Circuits to create blocks of DSP datapath logic using VHDL-based tools.

DESCRIPTION: Very High Speed Integrated Circuit Hardware Description Language (VHDL) is an IEEE standard language for the definition of digital systems. Many commercial design tools are available for building VHDL descriptions and creating their associated physical layouts. These commercial tools are generally targeted to support Application Specific Integrated Circuit (ASIC) implementations in commercial foundry processes, and not radiation-hardened foundry processes. A current Air Force need exists to develop a generalized VHDL Digital Signal Processing (DSP) module generator targeted to radiation hard foundries and critical space satellite applications with operating clock frequencies greater than 100MHz. The VHDL DSP module generator is to be developed for use in relation to custom Very Large Scale Integrated (VLSI) circuit designs implementing hardware DSP functions. Integral to the VHDL DSP module generator shall be a set of parameterized DSP "modules" that implement dedicated DSP functions and may include: Fast Accumulator, Array Multiplier, Finite Impulse Response Filter, Fast Fourier Transform, Digital Correlator, Histograming Memory, Numerically Controlled Oscillator, and Digital Down Converter. User-defined parameters shall include, but not be limited to: control signal polarities, datapath width, and speed vs. area. The DSP module generator shall be capable of targeting an associated radiation-hardened ASIC parts supplier's library, automatically creating a VHDL model of the DSP function and creating a correct-by-design physical layout of the DSP function. A proof-of-concept demonstration of the overall software design shall entail 1) creating a graphical user interface-based generator of selected DSP "modules" (selected through joint Air Force/contractor agreement), 2) targeting a radiation-hardened library from one or more radiation-hardened parts suppliers, 3) automatically generating the modules' associated VHDL design information, 4) automatically generating the modules' associated physical layout, and 5) demonstrating the simulation fidelity between physically extracted timing data versus generated VHDL module timing data.

PHASE I: Activity shall include (but not be limited to): 1) identification of a candidate set of parameterized, VHDL DSP generator "modules", 2) design of a comprehensive overall system level, 3) demonstration of VHDL DSP module generator integration with existing Electronic Design Automation (EDA) ASIC design flow, and 4) an Air Force/contractor agreed-upon preliminary demonstration of system building blocks.

PHASE II:Activity shall include (but not be limited to) 1) completion of the VHDL-based radiation hardened DSP module generator software system, 2) fabrication of the generated DSP modules for use in the demonstration of the simulation fidelity between physically measured timing data versus generated VHDL module timing data, and 3) full-scale demonstration of the system in accordance with the above (Description Section) requirements.

PHASE III DUAL USE APPLICATIONS: VHDL is emerging as an industry standard input description language of simulation and synthesis of ASIC designs. Successful development of a radiation-hardened VHDL-based DSP module generator, consisting of functions, possibly with different implementation, will have extensive application in the design of both DoD and commercial space-based digital signal processing equipment telephony, communications and resource imaging.

REFERENCES:

1. J.S. Calhoun, V.K. Madisetti, R.B. Reese, and T. Egolf, Developing and Distributing Component-Level VHDL Models, Journal of VLSI Signal Processing 15, pp111-126, 1996.
2. C. Meyers, R. Dreiling, VHDL Modeling for Signal Processor Development, Proceedings of the 1995 20th International Conference on Acoustics, Speech, and Signal Processing (Part 4 of 5), pp. 2699-2702, 1995.
3. C. Deltoso et. al, Fast Prototyping Based on Generic and Synthesizable VHDL Models. A Case Study: Punctured Viterbi Decoders, Proceedings of the Seventh IEEE International Rapid System Prototyping Conference, pp.158-163, 1996.

KEYWORDS: ASIC design, rad hard VLSI, automated IC layout, ASIC module generator, digital signal processing, automated VHDL generation

AF99-051 TITLE: Satellite Vehicle Tracking via S-Band Maser and Adaptive Optics

TECHNOLOGY AREA: Sensors

OBJECTIVE: Create tunable S-Band maser to enhance satellite vehicle tracking accuracy.

DESCRIPTION: Current Air Force Satellite Control Network (AFSCN) satellite vehicle tracking is accomplished using two-way S-Band communication links between parabolic ground antennas and satellite vehicles. Two inherent weaknesses of the parabolic antennas with respect to satellite vehicle tracking are 1) the relatively large angular spread of the main beam lobe at S-Band frequency, and 2) the existence of significant side lobes at S-Band frequency. Both of these weaknesses can, and sometimes do, negatively impact satellite vehicle tracking accuracy, especially if the satellite vehicle's transponder is down. Both of these weaknesses are caused by the physics of electromagnetic waves and parabolic antennas. A tunable S-Band maser beam addresses both of the weaknesses of parabolic antennas, because the maser's main beam width depends on the size and shape of the resonant cavity, and no side bands of any consequence exist. Laser technology has matured to the point where some manufacturing techniques and control systems could possibly be migrated to maser systems (e.g., tunable lasing systems, low flutter, low drift, low power, high temporal and spatial coherence). By supplementing a parabolic antenna with an S-Band maser, a ground antenna site would be able to accurately track anomalous or "silent" satellite vehicles. Also, an S-Band maser would be able to deliver a signal with high EIRP to a satellite vehicle without blanketing the surrounding area with side lobe radiation, as a parabolic antenna does.

PHASE I: Setup and test an S-Band maser prototype using COTS equipment. The maser should be tunable through the entire S-Band in order to be fully compatible with AFSCN-supported satellite vehicles, and the maser pointing system should be compatible with current AFSCN "antenna pointing angle" input signals. Phase I also includes experimentation of adaptive optics concepts into the S-Band region. Optical phase conjugation, phase conjugation mirrors, and atmospheric distortion compensation should attempt to be migrated from current laser technology to maser technology.

PHASE II:Create a powerful (> 0.5 kilowatt) proof-of-concept S-Band maser equipped with at least one adaptive optics capability (migrated from laser adaptive optics in Phase I). The Phase II maser would be tested by being slaved to an existing tracking antenna and illuminating an existing satellite vehicle to determine if a significant increase in range/range rate accuracy can be demonstrated. Range and range rate tests should include one-way (passive satellite vehicle) and two-way (active satellite vehicle transponder) measurements in order to measure differences between the tracking processes.

PHASE III DUAL USE APPLICATIONS: S-Band masers have the desirable characteristics of spectral purity, relatively tight beamwidth, high EIRP for relatively low power input, and minimal weather distortion. Commercial and military satellite vehicle operators will be needing these characteristics in order to maximize capability and minimize cost of their ground systems.

REFERENCES:

1. Pepper, David M., "Time Reversed Light", Scientific American, Vol 254 No. 1, pp. 74-83, Jan 1986.
2. Zeldovich, Boris, "Optical Phase Conjugation", Scientific American, Vol 253, No. 12, pp. 54-59, Dec 1985.
3. Zeldovich, Boris, "Principles of Phase Conjugation", Springer-Verlag, 1985.

KEYWORDS: maser, S-band, adaptive optics, optical phase conjugation, phase conjugation mirrors, satellite vehicle tracking, atmospheric distortion compensation

AF99-052 TITLE: Method for Near Optimal Antenna Placement for Satellite Operations

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop methods for optimal placement of antennas/ground stations against given satellite operation requirements.

DESCRIPTION: Antennas are used by satellites to provide communication between satellites in orbit and ground stations for the purpose of satellite tracking, maintenance, and dissemination of payload data. These ground stations are major contributors to the overall cost of satellite control networks. Part of the solution to reduce the high cost of satellite network operations is to optimally place ground antennas for minimal number of antennas and ground stations while still meeting the required level of satellite support. However, there has been very little open research in determining an optimal placement of antennas/ground stations for concurrent multiple satellite operations while satisfying many constraints in temporal and location dependency, priority, criticality and other resource scheduling factors. It is a very complex nonlinear global minimization problem with many operating constraints and there is no known analytical method to provide an exact optimal solution to this problem. The purpose of this research is to develop methods, algorithms and analytical solutions that can determine optimal placement of ground antennas to concurrently support many satellites. The resulting placement should be at least near optimal to satisfy users, contact support requirements and maximize network performance and utilization. The methods formulated will be assessed in terms of their optimality, adaptability, generality, testability, and extensibility.

PHASE I: The Phase I activity shall include: 1) the characterization of the antenna placement problem for satellite network operations based on the inputs provided, 2) the development of a set of metrics for the measurement of network performance, optimality and cost effectiveness, 3) the establishment of a set of evaluation criteria for ranking different antenna placement sets, and 4) the formulation of methods, algorithms and analytical solutions for optimal placement which will meet satellite support requirements against a given set of constraints. Details of the methods and analytical solutions shall be documented in a technical report.

PHASE II:The Phase II activity shall include: 1) the implementation of the methods/algorithms/analytical models developed in Phase I as a computer based evaluation tool, 2) construction of a representative set of test input scenarios based on AF Satellite Control Network (AFSCN) operations with assistance from SMC/CWI, 3) the execution and experimentation of the antenna placement methods driven by the test scenarios, 4) comparison between the performance and efficiency of each candidate method by assessing the cost effectiveness of the antenna placement sets generated, 5) identification of new technical issues related to the practicality of the candidate methods and additional technology needs, and 6) detailed documentation of all technical results and lessons learned from the Phase II activities.

PHASE III DUAL USE APPLICATIONS: The optimal antenna placement methods developed from this research will be applicable to a wide range of military and commercial satellite control networks that desire cost effective operations.

REFERENCES:
1. Larson, W. J. and Wertz, J. R., "Space Mission Analysis and Design," 2nd Ed., Microcosm, Inc. and Kluwer Academic Publishers, 1993.
2. Abbott, R. J., Campbell, M. C., Gallini, T. E., Moran, P. J., and Schulenbury D. J., "Automated Scheduling in the Satellite Control Network," Aerospace Report No. TOR-96(1571)-1, 30 January 1996.
3. Shang, Y. and Wah, B. W., "Global Optimization for Neural Network Training," IEEE Computer, 45-54, March 1996.
4. Ertas, A. and Jones, J. C., "The Engineering Design Process," 2nd Ed., John Wiley & Sons, Inc., 1996.

KEYWORDS: optimal, antenna placement, global minimization, analytical solution, satellite network operations, network of ground based antennas

AF99-053 TITLE: Passive Instrument to Determine Propagation Effects

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop an instrument that measures propagation factors at frequencies of interest for military/commercial communication systems.

DESCRIPTION: This project concerns the military/commercial need for the design and development of a measurement system that determines the atmospheric effects on radio propagation in an earth-space path. The basic requirement is for a three frequency radiometer with appropriate data acquisition and recording capability, all suitable for field use. The instrumentation developed will be used to perform measurements at sites of interest for military and commercial users. The principal frequencies of interest are 20, 30, and 44 GHz. In recent years there has been a large effort in measuring and modeling rain attenuation and this effort is still continuing; however, some current systems operating at EHF (extremely high frequency) utilize field terminals with small apertures which consequently have small link margins. For these terminals, particularly at low elevation angles, clouds and gaseous absorption can cause a link outage. Unfortunately, cloud attenuation statistics data are not available to develop a viable global cloud model. This proposal is a step to provide the basis for characterizing attenuation in non-raining, cloudy conditions. The system is also required to be capable of measuring attenuation when it is raining. Contact with existing programs that use radiometers for measurements (such as the advanced communications technology satellite [ACTS], and National Oceanic and Atmospheric Administration [NOAA] programs) is strongly suggested prior to design/development of the instrument required for this project. It may also be advantageous to consider some coordination or collaboration with these programs. It is desirable to use commercial-off-the-shelf (COTS) hardware wherever possible to minimize cost and enhance subsequent manufacture. It is also desirable to have a single antenna to cover the frequency ranges indicated. Prior to instrument design, the approach to several key issues (among others) must be determined: 1) how the measurements should be made, 2) how data acquisition should be implemented to avoid data-taking when no attenuating medium is present, 3) how to calibrate and validate measurements, 4) what the need for ancillary data such as temperature, humidity, rain gauges, etc. is, and 5) other issues, including the requirements of dynamic range, fade dynamics, and statistics of outage.

PHASE I: 1) Develop preliminary design of radiometric instrument system, 2) with Air Force assistance, check adequacy of design parameters with other existing programs that utilize radiometric instruments to ensure compatibility of usage, and 3) develop prototype design/test plan and demonstrate mutually agreed-to key elements of the design.

PHASE II:1) Finalize radiometer design, 2) fabricate radiometric instrument system, 3) finalize test plan, and 4) complete test plan with Air Force assistance. Measurements should be performed at global ground sites of interest to military and commercial organizations in order to establish a comprehensive database on attenuation at the frequencies identified.

PHASE III DUAL USE APPLICATIONS: The military space system frequency allocations are 20 GHz for downlinks and 44 GHz for uplinks. The commercial space system allocations are 20 GHz for downlinks and 30 GHz for uplinks. Therefore, the measurement instrument to be designed for the three frequencies identified will provide dual use to DoD/commercial interests alike.

REFERENCES:

1. "A Dual-channel Microwave Radiometer for Measurement of Precipitable Water Vapor and Liquid," Guiraud, F. O., Howard, J., and Hogg, D.C., IEEE Trans. Geosci. Electron GE-17, 129-136, 1979
2. "ACTS Propagation Experiment: Experiment Design, Calibration, and Data Preparation and Archival," R. K. Crane, X. Wang, D. B. Westenhaver, and W. J. Vogel, Proc. IEEE, Vol. 85, 1997.
3. "Ground-based Radiometric Observations of Atmospheric Emission and Attenuation at 20.6, 31.65, and 90 GHz: A Comparison of Measurement and Theory," E. R. Westwater, J. B. Snider, and M. J. Falls, IEEE Transactions on Antennas and Prop., Vol. 38, 1990.

KEYWORDS: earth-space path, global measurement, attenuation models, radio propagation, measurement system, atmospheric effects, propagation factors

AF99-054 TITLE: Generalized Guidance and Control Computer Program

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop a modern G&C software tool featuring a structured input language, a trajectory simulator, and output targeted to user-designated architectures.

DESCRIPTION: After nearly 50 years of spaceflight, custom-built computer programs are still being developed to perform the Guidance and Control (G&C) functions for individual families of aerospace vehicles. Each of these programs is concerned with performing identical functions, namely: 1) process input data from sensors and command devices, 2) determine guidance and control errors, 3) apply the appropriate steering and control laws, and 4) output commands to remain on course while maintaining a stable attitude. A pervasive need exists for a generalized, G&C software tool featuring a structured input language, a trajectory simulator, and output targeted to user designated architectures. The system should be highly modularized to allow for simulation and application to a wide variety of systems including reentry vehicles, launch vehicles, orbiting satellites and aircraft. Basic features of the system (among others) should include: 1) a problem-oriented, user-friendly input language, 2) a library of support functions commonly required for trajectory and G&C functions, 3) a system for event detection, 4) differential equation solvers that are functionally isolated from the physical models, 5) allowing targeting by simply changing the input data base, thus not requiring revalidation for every flight, and most importantly 6) the proof that the concept is viable.

PHASE I: 1) Develop an overall system architecture/design, 2) develop actual code to show feasibility of critical system components; ensure that both the development environment and the system product use the same input systems, and 3) provide a demonstration of critical system elements.

PHASE II:1) Finalize the G&C system, 2) develop an operating example of the G&C system developed from the same statement of system requirements that were used to develop (a mutually agreed-to) existing system, and 3) run a parallel comparison of the new G&C system and the selected existing system so that comparison of results can be used to demonstrate the validity of the new system.

PHASE III DUAL USE APPLICATIONS: A successful, modular, generalized G&C system would be utilized by military and commercial boosters, satellites, and reentry systems.

REFERENCES:

1. Dhuyvetter, Henry, "A New Guidance and Flight Control System for Delta II", AAS 93-068, 16th AAS Guidance and Control Conference, Feb 6 to 10, 1993.
2. Meder, Dale S., McLaughlin, John R., "A Generalized Trajectory Simulation System", 1976 Summer Computer Simulation Conference, Washington, D.C., July 12 to 14, 1976. Sponsored by AICHE, ISA, SHARE, SCS, AMS, AIAA, IEEE, AGU, BMES, IAMCS.

KEYWORDS: targeting, space vehicle, trajectory simulator, structured input language, guidance/control functions, user-designated architecture

AF99-055 TITLE: Satellite Onboard Set Scan Processor

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Design a built-in self test processor to monitor ASICs health and provide processed test information to a redundancy controller.

DESCRIPTION: A specialized processor is needed to support built-in self tests of complex signal processing functions in DoD and commercial satellite payloads. A special purpose processor, local to a processing unit, will reduce the load on the spacecraft computer by performing low-level health and status checks, detecting anomalous operation, conducting self tests, and reporting results to the redundancy control computer which may be located either onboard or on the ground. The built-in self test processor will monitor data buses to detect parity errors, control boundary scan or signature analysis operations, and connect to digital signal processor or application-specific integrated circuits (ASIC) chips via the IEEE 1149.1 interface. The built-in self test processor receives results of checks, tests, or polling operations, and then removes redundancy and formats the data for transmission to the redundancy control computer. Innovation is required to provide flexibility and programmability so that the built-in self test processor can be configured to support a range of redundancy configurations. While conforming to standard interfaces (e.g., IEEE 1149.1), the built-in self test processor will control several types of self tests, interpret results, and format the data for either onboard or downlink transmission. The test procedures and data formatting shall be programmable to facilitate interfacing with different user architectures and designs. Government input as to specific processor requirements shall be provided.

PHASE I: Develop an architecture for the processor which will implement test and monitoring functions while providing flexibility and programmability. The processor architecture shall include a means for fault detection and a means for either bypassing the processor or providing fault recovery. The results shall be documented in a report and a plan for a prototype development in Phase II shall be included. Mutually agreed-to key elements of the processor shall be simulated/demonstrated.

PHASE II:Develop a working prototype of the built-in self test computer. The processor shall interface with real and emulated ASICs to demonstrate the recognition of anomalies and the processing associated with error reporting and redundancy removal. The prototype processor shall demonstrate how it operates with a simulated payload redundancy management system. A plan for radiation hardening and flight qualification shall be provided, as shall estimates of the size, weight, and power.

PHASE III DUAL USE APPLICATIONS: The built-in self test processor should be useful for either military or commercial satellites. New commercial satellite designs for personal communications and high speed Internet access employ constellations with a large number of satellites. These applications can benefit directly from a space qualified built-in self test processor regardless of whether the built-in self test processor is used onboard or only in the spacecraft integration and test. The built-in self test processor will be a useful element in any commercial system employing ASICs and requiring either a robust design or full fault tolerance. Commercial aircraft and telephone switching are two examples where fault tolerant processing or computing is required. The built-in self test processor may also be useful in reducing costs of testing for any sophisticated electronic system.

REFERENCES:

1. Daniels, R. Gary, et. al., Built-In Self Test Trends in Motorola Micro Processors, IEEE Transactions Design and Test, Dec. 1985.
2. Dear, I. D., Economic Effects in Design and Test, IEEE Design and Test for Computers, Dec. 1991.
3. IEEE 1149.1 Specification.

KEYWORDS: parity errors, fault tolerance, data compression, built-in self test, signature analysis, redundancy control,set scan processing, satellite communications

AF99-058 TITLE: Automatic Test Pattern Generation (ATPG) Tool Development

TECHNOLOGY AREA: Modeling and Simulation (M&S)

OBJECTIVE: Identify causes for errors and discrepancies between industry standard ATPG tools, compare results with deterministic tools, and develop an accurate ATPG.

DESCRIPTION: Critical processing applications such as banking, medical electronics and space electronics require a high degree of confidence that the electronic components are operating within specification. In particular, validating the performance of Application Specific Integrated Circuits (ASICs) at the device level both reduces the cost and schedule impacts of subsystem and system integration and minimizes the possibility of outage from anomalous circuit behavior during the operating lifetime of the ASIC. ATPG tools provide screening vectors to thoroughly test ASICs. There currently is no way to verify the accuracy of ATPG-based tests. In the absence of verifiable accuracy, ATPG manufacturer fault coverage claims cannot be substantiated.

PHASE I: 1) In cooperation with the Air Force, assess the relative accuracy of the most commonly used industry standard ATPG tools based upon measurement of a large variety of representative ASIC circuits. 2) Establish the absolute ATPG accuracy for each representative circuit by comparing the ATPG benchmark results to those obtained by the use of deterministic fault grading tools (those that do not make assumptions or use ATPG algorithms) on the identical representative circuits. 3) Based upon comparison of results, develop the architecture/specification for an improved accuracy ATPG tool. 4) Demonstrate key elements of the improved ATPG tool to provide confidence in the integrity of the concept.

PHASE II:1) Develop a fully functional prototype of the improved accuracy ATPG tool. 2) Apply the improved accuracy ATPG tool and selected deterministic fault grading tools to the measurement of a common set of ASIC circuits and compare the results. 3) Modify the improved accuracy ATPG, if required, and repeat the comparison process until the improved accuracy ATPG tool meets specification.

PHASE III DUAL USE APPLICATIONS: Applications Specific Integrated Circuits (ASICs) are used extensively in commercial and military satellites. As ASICs gate counts increase, the fault coverage accuracy of ATPG tools will become increasingly important in order to assure testing quality/integrity. In particular, it is crucial that ASICs be completely and accurately tested in order to mitigate the risk of a faulty chip ending up on a satellite space system or in thousands of personal computers which would result in costly schedule setbacks, troubleshooting, and repairs.

REFERENCES:

1. M. Lee, High Level Test Synthesis for Digital VLSI Circuits, Airtech House, 1997.
2. V. Agrawal, Tutorial, Test Generation for VLSI Chips, IEEE Computer Society, 1988.

KEYWORDS: ASIC circuits, screening vectors, verifiable accuracy, anomalous circuit behavior, deterministic fault grading tools, automatic test pattern generation

AF99-059 TITLE: Transportable Standard IR Calibration Source

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop a transportable standard IR calibration source.

DESCRIPTION: DoD, NASA and commercial satellites are using more and more of the IR spectrum for object surveillance, detection discrimination, and identification. These systems are utilizing state-of-the-art sensors with constantly improving detectivities. Older radiometric test chambers are being upgraded, and new ones are being constructed to test and calibrate these new sensors. However, spectroradiometric IR calibration sources have not kept pace with IR chamber testing and calibration requirements for these sensors working at detectivities below 10(-10) watts/square cm/sr/micron. The objective of this project is the development of a transportable standard (radiometric) IR calibration source (covering the spectroradiometric range of 0.5-15 microns). If met, this objective will fill a void in current calibration and testing capabilities for such sensitive detectors, and will allow military surveillance and MASINT (management of measurement and signature intelligence) users, Government/Academic research and the Commercial earth resources communities, to take advantage of sensor performance improvements, resulting from significantly improved IR ground calibration resources. The result will be that users will be able to extract far more useful information from data collected from the IR sensors. The design requirements for the subject standard IR calibration source (among others) include: 1) that it be an easily transportable, point and constant flux diffuse source calibration instrument(s), covering the spectroradiometric range of 0.5-15 microns, and 2) that it be generically compatible with a wide variety of radiometric test chambers. The issue of compatibility with (modernized) existing and new radiometric test chambers should be based upon a thorough facilities/capability analysis of DoD/Academic/Commercial radiometric test chamber resources.

PHASE I: 1) Collect background information/data on existing and new radiometric test chambers; 2) integrate the data collected and develop specifications/preliminary design for a transportable point and constant flux diffuse source (or family of sources) radiometric calibration instrument, covering the 0.5-15 micron range; and 3) demonstrate (mutually agreed-upon) key elements of the design to provide confidence in a successful Phase II project.

PHASE II:1) Complete the design, engineering development, fabrication, functional testing and calibration to known standards for the transportable spectroradiometric instrumentation, and 2) provide a fully functional demonstration to Air Force specifications.

PHASE III DUAL USE APPLICATIONS: Successful development of the transportable spectroradiometric calibration instrumentation will avail a resource to DoD/NASA/Commercial satellites which will result in significantly improved (object surveillance, detection discrimination, and identification) IR sensor performance.

REFERENCES:
1. Smith, M. W., "Design and Initial Performance Evaluation of a Portable Short Wave Infrared Spectroradiometer," Proceedings of the SPIE - The International Society for Optical Engineering, vol. 1762, p. 118-134, 1992.
2. Yafuso, E. S., Dereniak, E. L., "Infrared Portable Calibration Unit," Proceedings of the SPIE - The International Society for Optical Engineering, vol. 1762, p. 89-96, 1992.
3. Wyatt, C. L., Jacobsen, L., Steed, A., "Portable Compact Multifunction IR Calibrator," Proceedings of the SPIE - The International Society for Optical Engineering, vol. 940, p. 63-72, 1988.
4. Kuhlow, W. W., Laboratory and Field Portable System for Calibrating Airborne Multispectral Scanners, Department of Energy, Washington DC, Report No.: EGG-1183-1777: CONG-810810-23, 1981, 5p. (NTIS: DE81029740).

KEYWORDS: sensors, infrared spectrum, radiometric source, object surveillance, detection discrimination, radiometric test chamber, spectroradiometric IR calibration

AF99-060 TITLE: Emerging Technologies in Training Development

TECHNOLOGY AREA: Manpower, Personnel, and Training

OBJECTIVE: Develop less labor-intensive methods of instructional development.

DESCRIPTION: The current trend in satellite control (as is the trend in many military and commercial areas) is to move from highly trained and highly educated satellite operators to a small cadre of lower skilled operators with engineering support (front room/back room concept). This trend also impacts mission analysts, spacecraft designers, and warfighting commands assessing space-based concept of operations and applications of future space technologies. One of the challenges of this method of operation is to provide adequate, effective, low cost, comprehensive training and education for these lower skilled operators and those developers/planners/users new to the space community. Automated training has the potential to provide effective, low cost training/education. However, developing automated training/education using current technology is a highly labor-intensive process, requiring 200-600 hours of construction time for every hour of instruction. A need exists to develop an innovative, highly cost effective automated training development technology which will avail automated training instruction methodology to a broad range of military and commercial training requirements. In relation to the Air Force requirement for satellite operators, the following issues (among others) should be addressed: 1) cost efficient use of artificial intelligence (AI) in training, 2) task analysis of satellite operation, 3) portability and interoperability of training systems with operational requirements, 4) maintenance/support of training systems, and 5) use of modeling and simulation to support training/educational requirements for individuals new to the space community in positions from research and development, to satellite operators, to command staff levels.

PHASE I: 1) Develop an architecture for a generalized method of efficient development of automated instruction, and 2) develop a prototype system and demonstrate mutually agreed-to key elements of the system.

PHASE II:1) Refine and finalize the methodology for development of automated instruction, 2) develop an automated training instruction vehicle (with Air Force cooperation and input) for training satellite operators, 3) test the effectiveness of the training system (with Air Force assistance) on actual satellite operators, and 4) transition the system to another satellite family and demonstrate the generality of the design.

PHASE III DUAL USE APPLICATIONS: The technology developed under this program will have a high commercialization potential, applicable to virtually any training environment in the government or civilian sector. One of the biggest barriers to widespread use of automated training is the prohibitive cost. Development of new techniques for creating this training should serve to greatly increase the sphere of environments over which automated training can be utilized. Both military and commercial satellite operators will benefit from this technology.

REFERENCES:
1. Jiang, M. Z., Sittig, D. F., Developing Interactive Computer-based Simulations: an Object-oriented Development Methodology Enhances Computer-assisted Instruction, Source: Computer Methods and Programs in Biomedicine, V. 47, N. 3, August 1995, p. 189-196.
2. Bourdeau, J., Junginger, S., et al., Automating Instructional Planning, Conference: Proceedings of the NATO Advanced Study Institute on Automating Instructional Design: Computer-Based Development and Delivery Tools, 12-23 July 1993, Grimstad, Norway, p. 559-569. Publisher: Springer-Verlag, Berlin, Germany, 1995, 618pp.
3. Tennyson, R. D., Spector, J. M., Muriada, D. J., Automation and Instructional System Development, Proceedings of the NATO Advanced Research Workshop on Automating Instructional Design, Development and Delivery, 23-27 March 1992, Sitges, Spain. Publisher: Springer-Verlag, Berlin Germany 1994, 266 pp.

KEYWORDS: satellite control, automated training, satellite operators, intelligent systems, artificial intelligence, instruction methodology

AF99-061 TITLE: Advanced Cryocooler Technology

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop and demonstrate cryocooler technology for next generation spacecraft cooling applications.

DESCRIPTION: Next generation space infrared sensing technologies and spacecraft cryocooling needs will require revolutionary improvements in cryocooling technology. Exploitation of technology with minimal or no moving parts, minimal mass, minimal input power, minimal vibration, high efficiency, and high reliability are essential to meet cryocooling goals for shrinking Air Force (AF) and Department of Defense (DoD) infrared sensing payloads. Specific interests include, but are not limited to, advanced thermoelectric coolers, low temperature (near and below 10 K) regenerators, laser or fluorescent cooling, cooling across a gimbaled joint, and continuous sorption cooling. In addition to these needs, producibility, reliability, and manufacturability are important to AF and DoD applications.

PHASE I: Demonstrate the adaptation of an innovative technology in a breadboard format. This can include demonstration of a fundamental physical principle in a format that illustrates how this technology can be utilized in a cryocooler. This effort should include plans to further develop and exploit this technology in Phase II.

PHASE II:Develop an engineering design model device or cooler. This device may not be optimized to flight levels, but should be able to demonstrate the ability of the contractor to create a working device. Demonstrate the potential improvements in mass, input power, efficiency, and/or reliability. The contractor should keep in mind the goal of commercialization of this innovation.

PHASE III DUAL USE APPLICATIONS: Applications of this technology potentially could be far reaching. Typical AF and DoD military space applications relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. Specific examples include the track sensor (~0.5 W @ 35K and 60K), and gimbaled optics (~6-10 W @ 100K) cooling for the SBIRS Low EDM system. Another key area of interest is in the (0.1-2 W @ 4-10K) range in support of military, NASA, civil, and commercial users. These user applications include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. However, the need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. If the developed innovation is low cost, potential applications include CMOS cooling of workstations and personal computers.

REFERENCES:

1. Overview of Air Force Phillips Laboratory Programs, International Cryocooler Conference, (1997) L. Crawford and C. Kalivoda, Phillips Lab, Kirtland AFB NM; and David Glaister, Aerospace Corp, NM, Plenum Press, New York and London
2. Design and Development of a 20K Stirling-Cycle Cooler for FIRST, International Cryocooler Conference, (1997), S. Scull and B. Jones, Matra Marconi Space, UK; T. Bradshaw and A. Orlowska, Rutherford Appleton Laboratory, UK; and C. Jewel, ESA, the NETHERLANDS, Plenum Press, New York and London
3. The Los Alamos Solid-State Optical Refrigerator, International Cryocooler Conference, (1997), R. Epstein, B. Edwards, C. Mungan and B. Buchwald, LANL, Los Alamos, NM, Plenum Press, New York and London
4. Two-Stage Double-Inlet Pulse Tube Refrigerator down to 10K, International Cryocooler Conference, (1997), S. Wild and L.Oellrich, University of Karlsruhe; and A. Hofmann, Forschungszentrum Karlsruhe, GERMANY, Plenum Press, New York and London
5. Development of a 2 Watt class 4K Gifford-McMahon Cycle Cooler, International Cryocooler Conference, (1997), T. Inaguchi, M. Nagao, and Naka and H. Yoshimura, Mitsubishi Electric Corp, Hyogo, JAPAN, Plenum Press, New York and London

KEYWORDS: space, cooling, cryogenics, cryocooler, infrared sensors, thermal management, cryogenic refrigerator

AF99-062 TITLE: Space Vehicles Technology Development

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop innovative methods for improving the performance, endurance and survivability of future space and missile systems.

DESCRIPTION: Future space systems require a variety of integrated technology developments in order to meet improved performance requirements. We are seeking innovative approaches and technology developments which will provide effective and affordable future space vehicles, launch vehicles and space concepts with improved space system performance, endurance and survivability. Proposed approaches shall emphasize dual use applications, i.e., those which clearly offer private sector as well as military applications. Proposals emphasizing technology transfer will receive additional consideration. Areas of interest include:

Surveillance and Control Technologies: Advanced technologies which revolutionize space-based surveillance and space operations. This includes technologies in infrared focal planes, cryocoolers, hyperspectral imaging, satellite control/autonomy, satellite guidance and navigation, astrodynamics, radiation hardened electronics, space debris analysis, threat warning and attack reporting, and modeling and simulation.

Space Technology Integration and Demonstration: Innovative approaches for the development, integration and demonstration of emerging vehicle technologies and space concepts in the areas of thermal management, space power/energy storage, and space structures and controls.

Battlespace Environment: Technologies enabling the detection and understanding of threats in the aerospace environment to space systems across the full range of natural and man-made sources as well as passive and active means to eliminate or mitigate those threats. Specific areas include solar activity effects, ionospheric impacts, space hazard mitigation, radiation environment characterization, atmospheric modeling, space background characterization, and space weather impact decision aids.

PHASE I: Develop concepts and perform analyses to establish the feasibility of the proposed approach.

PHASE II:Complete the Phase I design and develop a demonstrator or prototype. Document the research and development and develop a technology transition and/or insertion plan for future systems and commercial ventures.

PHASE III DUAL USE APPLICATIONS: Space systems for DoD and commercial use require advanced technologies that are highly reliable, high performance, and survivable to a wide variety of man-made and natural environments. These technologies have immediate and definite commercialization potential in consumer goods and infrastructure improvements.

REFERENCES: Bednarz, Eugene, "Space Vehicles Technologies," Point Paper, Apr 98; web site addres: TBD.

KEYWORDS: atmospheric modeling, hyperspectral imaging, space-based surveillance, pace-power/energy storage, satellite control/autonomy, satellite navigation/control, rad-hard/tolerant electronics, space structures and controls, radiation environment mitigation, space-background characterization

AF99-063 TITLE: Self-Consuming Satellite

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop/evaluate satellite architectures that save weight by using the satellite structure as a propellant.

DESCRIPTION: The traditional approach in designing satellites is to structurally stiffen the satellite so that it will survive during the launch environments; once on-orbit, the satellite structure mass is no longer needed. This approach is a very inefficient way to design satellites, considering the fact that a kg of mass costs tens of thousands of dollars to put into space. Therefore, it is necessary to devise different ways to structurally stiffen the satellite so that the stiffening elements can be used for other purposes. One such concept is to have the satellite propellant be a part of the satellite. Therefore, this program shall develop a new satellite architecture that will incorporate the satellite's propellant in the satellite structure. Weight and volume reductions in the satellite will be accomplished by using the propulsion system's propellant as part of the load-bearing structure of the satellite.

PHASE I: Define the most promising propulsion concepts that can be used as load bearing structures. Perform a preliminary structural analysis on the most promising concepts to determine the feasibility of a self-consuming satellite. This will include incorporating propulsion requirements such as delta-V requirements, the number of thrusters, etc., as well as structural requirements such as weight, launch loads and stiffness.

PHASE II:Demonstrate concepts defined during Phase I with a prototype satellite structure. A detailed structural analysis will be performed on the most promising concepts, and a demonstration article shall be built and tested to verify results of the detailed analysis. Performance testing shall include subjecting the demonstration article to actual launch conditions.

PHASE III DUAL USE APPLICATIONS: Reduction of satellite weight is an important consideration for both military and commercial space industry. Therefore, there is a large market for a self-consuming satellite that makes use of the existing satellite load-bearing structure.

REFERENCES:
1. Helvajian, H., Janson, S. W., Robinson, E. Y., "Big Benefits from Tiny Technologies: Micro-Nanotechnology Applications in Future Space Systems," Advancement of Photonics for Space, 1997.
2. Janson, S. W., Helvajian, H., "Batch Fabricated Microthrusters: Initial Result " 32nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference. AIAA 96-2988, 1996.
3. Epstein, A. H., Senturia, S. D., et al., "Micro-Heat Engines, Gas Turbines, and Rocket Engines - The MIT Project," 28th AIAA Fluid Dynamics Conference. AIAA 97- 73, 1997.
4. Bayt, R. L., Ayon, A. A., Breuer, K. S., "A Performance Evaluation of MEMS-based Micronozzles, "33rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit. AIA 97-3169, 1997.

KEYWORDS: MEMS, cannibalization, micropropulsion, digital propulsion, structural stiffening, self-consuming structures

AF99-064 TITLE: MEMS Integration for Micro-Spacecraft

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop micro-machining, MEMS, and meso-scale electro-mechanical approaches for advanced microspacecraft applications in these fields.

DESCRIPTION: New advances in the fields of micro-machining, MEMS, and meso-scale electro-mechanical approaches, when combined, are expected to provide enabling benefits in the capability of space systems. Space systems need improved power and thermal management, propulsion, sensor integration, and embedded electronically-activated actuator assemblies. Micromachining technologies, especially those pertaining to silicon, have evolved over the last several decades. They suggest the possibility of extraordinary efficiencies in their functional domain as compared to their "macro-machined" analogs, alleviating bulk in the replaced component and reducing next-level structural interfaces, cooling/heating requirements, etc. While promising developments have been reported, many micromachining concepts remain lab curios.

Finding MEMS applications for spacecraft may be even more challenging. Few of the novel concepts have been shown useful to spacecraft--gyros do not have enough accuracy, actuators do not have a useful role, etc. We believe the categories for MEMS-based improvements include: improved thermal management, micro-encapsulated cryogenic coolers (for infrared focal plane arrays and detectors), positive component securing techniques, embedded multistable relays, micro-connectors, micro-propulsion, micro-optical systems, active control, etc. Practical technology insertion must be addressed, particularly noting the space environmental context of prospective applications. Also a chief issue is the efficient packaging of MEMS devices and co-integration with electronics. More than enabling size, weight, and power reduction, MEMS can also promote the significant issues of ease of integration through novel concepts that allow rapid and standard access and interchange of spacecraft panels, intra-panel components, and internal spacecraft bus systems.

PHASE I: Design and develop novel micro- and meso-scale electromechanical concepts. Address practical techniques to improve particular aspects of spacecraft systems. Many MEMS "toys" exist, and it is not the intent of this effort to build variations on "well-tread" themes. The ability of a Phase I concept to make an enabling difference to spacecraft bus or relevant payload size, weight, power consumption, or ease of integration is desired. Identify actual devices, and if possible, produce preliminary prototypes.

PHASE II:Demonstrate the repeatable, quality formation of components. Ties to spacecraft demonstrations are particularly important. We highly encourage cooperation and leveraging of existing technologies. Any third-party industrial or government offers of leverage in the Phase II effort and post-Phase II endeavors would be desirable. The results of a successful Phase II approach would lead to superior micro- and/or meso- devices and applications of those devices that could be inserted in certain space-based systems.

PHASE III DUAL USE APPLICATIONS: MEMS technologies are assessed as having multi-billion dollar market potential. Any breakthrough application in this SBIR will further enhance the utility of MEMS devices in terrestrial and commercial space.

REFERENCES:
1. James C. Lyke, M. Adrian Michalicek, and Babu K. Singaraju, "MEMS in Space Systems," presented at 1st International Micro/Nano-technology workshop, Oct-29 - Nov 2, 1995, Houston TX.
2. Lyke, James C. "Advanced packaging for Integrated Micro-instruments", presented at 1st International Micro/Nano-technology workshop, Oct-29 - Nov 2, 1995, Houston TX.
3. L. Muller, M.H. Hecht, L. Miller, H. Rockstad, T.K. Tang and J. Lyke, "Packaging and Qualification of MEMS-based Space Systems", presented at IEEE Int'l Workshop on Micro-electromechanical systems MEMS-96, Feb 11-15, 1996, San Diego, CA
4. Microengineering Technology for Space Systems, Aerospace Report No. ATR-95(8168)-2, 30 Sep 95, edited by Henry Helvajian.

KEYWORDS: network, crosslink, lightweight, high data rate, data transmission, miniature hardware, space communications

AF99-065 TITLE: Thermal Management for Advanced Packaging in Payload Electronics

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop innovative thermal management technologies for future large, wafer scale, space-based integrated circuits.

DESCRIPTION: Future space-based electronics systems will require innovative packaging solutions to enable space systems to meet size, weight, power, and lifetime reliability requirements. Commonly, these approaches are based on efficient 2-D and 3-D arrangements of electronics, often involving "multi-chip-modules" (MCMs). As chips are packaged closer together, the area/volume power density (heat flux) increases. It is conceivable that future packaging densities will be such that the resulting heat generated during operation cannot be removed fast enough with conventional heat-sinking schemes to sustain an equilibrium below critical operating temperatures. Innovative solutions are sought for modular heat removal from one or two faces (approximately 5cm x 10cm area for each face) of a 3-D stack of MCM substrates. Solutions must meet the following additional requirements: 1) it must allow for easy removal and replacement of the MCM stacks, 2) it must have a minimum conductance across the interface of 100 Watts/C-cm2, 3) it must operate in a space environment for a minimum of 10 years, and 4) it must transport a minimum heat flux of 20W/cm2. Examples of possible solutions include but are not limited to: pumped fluid loops, heat pipes, capillary pumped loops, looped heat pipes, and highly conductive epoxies/fillers. Although technology dependant assumptions may impact a solution (e.g. all-CMOS), emphasis should be placed upon innovative mechanisms that result in the removal of the required amount of heat.

PHASE I: Evaluate/develop conceptual designs for techniques that can provide significant thermal management improvements compared to the thermal management techniques used in conventional packaging approaches. Conduct proof-of-concept demonstrations to indicate the practicality of such techniques for use in military and space systems.

PHASE II:Construct a functional system which demonstrates the ability to remove high amounts of heat (the exact amounts will be established based primarily on Phase I analyses). The demonstrated system must be capable of operation under severe thermal, mechanical, and radiation environments. Furthermore, the constructed systems must demonstrate the feasibility of heat removal by simulating the electrical power loading of "typical" electronic systems and then demonstrate thermal equilibrium of this system in operation.

PHASE III DUAL USE APPLICATIONS: The thermal management techniques will find commercial application in projects of interest to government, industry, and academia, especially with respect to commercial space applications. The unique thermal boundary conditions of the space environment do not permit solutions widely used in terrestrial applications such as air-cooling. It is also possible in certain circumstances to find applications in other domains where large amounts of dense circuitry can be confined with limited airflow boundary conditions.

REFERENCES:
1. Dunbar, N.; Jacobs, R.; Supper, W. "Design, development and testing of a miniature capillary pumped loop". ESA, Noordwijk, Netherlands. Sixth European Symposium on Space Environmental Control Systems (ESA SP-400).
2. Bar-Cohen, A. et al. Advances in Thermal Modeling of Electronics Components and Systems. York, NewASME Press, 1990. (1986).
3. Moresco, Larry L. "Electronic System Packaging: The Search for Manufacturing the Optimum in a Sea of Constraints". IEEE Transactions on Components, Hybrids, and Manufacturing Technology: 13(3), September 1990.

KEYWORDS: heat pipes, multi-chip module, pumped fluid loops, thermal management, high flux heat transfer, conductive epoxies/fillers, high density electronics cooling

AF99-066 TITLE: Autonomous Control of Multiple Satellites Using Intelligent Software Agents

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Design and develop a multi-agent supported architecture which would be used to autonomously monitor and control multiple satellites.

DESCRIPTION: At the present time there is very little automation onboard Air Force satellites as relates to surveillance payload missions. Large amounts of data are collected from each satellite and downlinked to the ground where a variety of independent techniques are used to assess whether there exists any information of value. In addition, there is virtually no collaboration between satellites with respect to each others' position or knowledge about detected objects of interest. The amount of data collected and downlinked could be significantly reduced if more intelligence is placed onboard, providing the ability to process, detect, and interpret information onboard the satellite and adjust and/or configure sensors accordingly based on sensor data. A large number of past and current research efforts have focused on target recognition under a variety of different environments and scenarios. The focus of this research topic is to leverage off of that research and to develop a top-level onboard executive controller which would monitor and control the processing of satellite data and sensors. Each satellite's onboard controller would operate autonomously in cooperation with executive controllers onboard other satellites as well as ground-based controllers. Each of these controllers would act as top-level intelligent agents. The basic concept behind an intelligent agent is the notion of an independent software entity that operates within some environment (e.g., satellite sensing environment) while always attempting to achieve some goal (e.g., detecting entities, controlling sensor pointing, etc). Agents can have a simple task such as monitoring a battery voltage, or they can have a much more complex function such as detecting specific targets using technologies such as neural networks. The way each agent reacts and attempts to achieve its individual objective is based on stimuli received from other entities within the environment. Each of these top-level agent-based controllers would in turn communicate with lower-level agents which would have more specific tasks. The strength of the agent approach to satellite autonomy is the ability to react to uncertainty and changing mission requirements. A key to this research effort is the ability of the agents to cooperate with one another whether they reside on the same satellite or across different satellites. For example, an agent residing on one satellite may detect some object of interest and react accordingly. To optimize information processing, relevant information can be made available to a second satellite such that when the object comes within its field of view it can already be configured to optimize observation of the object in question. The notion of an intelligent agent-based controller can be extended to include health and status related satellite autonomy.

PHASE I: Develop a detailed design and description for this agent-based architecture for satellite payload autonomy. This will include, but not be limited to, the following: 1) mechanism by which agents communicate, 2) means by which a situational assessment is made based on the status of individual agents, 3) detailed description of the satellite surveillance domain and where and how various agents would be utilized, and 4) specification of the software and hardware platform to be used along with a description of the key software agents to be used. Of the above goals, inter-agent cooperation is considered most important. A prototype demonstration of the proposed architecture is desired.

PHASE II:Implement the design generated in Phase I and provide an in-depth demonstration of its capability. The architecture should be designed such that it can be extended easily to incorporate new agents as needs arise. Demonstration of this extensibility/flexibility is desired. Demonstrating this technology in an actual flight experiment is ideal; however, if time and cost prevent this, then the demonstration should be as realistic as possible with an easy migration towards a flight experiment.

PHASE III DUAL USE APPLICATION: Satellite autonomy is a critical concern in both military and commercial space industries to increase reliability while reducing operating costs. The concept of an intelligent agent architecture is not specific to satellite autonomy, but has applicability to any number of different domains. Any process which involves monitoring a number of different entities from different sources and providing a situational assessment based on all of these entities could benefit from such an intelligent agent-based architecture.

REFERENCES:

1. Zetocha, Paul, and Ortiz, James, "Phillips Executive Agent-Based Controller Helper (PEACH)," Proceedings of SpaceOps 98 Conference, Tokyo Japan, Jun 1997.

2. Nwana, Hyacinth, Software Agents: An Overview", UMBC Agent Web site - www.cs.umbc.edu/agents.

3. Hopkins, Kory, "An Examination of Agent Technologies", Simon Fraser University,
Web Site - www.cs.sfu.ca/cs/people/GradStudents/khopkins/personal/papers/agent_readings/index.html.

4. Agent Technologies HomePage, www.agenttech.com

5. Ballard, Dan, "Intelligent Agents and Agent Communication Languages for Mission Operations," Phase I SBIR Final Report by Reticular Systems, Contract #NAS5-33264, Jun 1996.

KEYWORDS: autonomous agents, intelligent agents, executive controller, agent communications, situation assessment, smart optical sensing, intelligent satellite control

AF99-067 TITLE: Advanced Diagnostic and Modeling Techniques for the Ionosphere and Upper Atmosphere

TECHNOLOGY AREA: Battlespace Environments

OBJECTIVE: Develop techniques for the characterization and environmental monitoring of ionosphere, and assessing radio-frequency propagation effects through ionosphere.

DESCRIPTION: Advanced diagnostic techniques for characterizing the earth's atmosphere above 50 kilometers are required for better determination of atmospheric effects on radio-wave propagation for civilian and military space-based communication, navigation, and surveillance systems. Therefore, advanced diagnostic and modeling techniques for the characterization of the ionosphere and upper atmosphere, as well as environmental monitoring of the ionosphere and upper atmosphere, are needed. Physical quantities of interest include neutral compositions, ion compositions, densities, temperatures, winds, collision frequencies, recombination rates, diffusion rates, scintillation parameters, and electric fields. Appropriate responses may include diagnostic techniques for ground-based remote measurements. Because the ground-based systems may be deployed to various world-wide locations that are often primitive and remote, the system should be easy to operate, maintain, and transport. The ability for the system to facilitate telescience research is highly desired. Responses may also include advanced modeling or numerical techniques that facilitate or augment ionosphere and upper atmosphere diagnostics. In addition to the natural atmosphere, consideration should be given to the diagnosis of atmospheric regions that are modified by powerful high frequency transmissions produced by facilities such as the High Frequency Auroral Research Program (HAARP); diagnostics specifically designed to work in conjunction with these transmitters are acceptable. Proposed diagnostics should assess the dual use commercialization potential and exploit commercial off-the-shelf components whenever possible. Responses may include proposals for instruments based on completely new diagnostic principles, improvements of known diagnostic techniques by exploiting recently available technology, or the development of new analysis techniques or human interface systems that substantially improve the information yield from existing diagnostics.

PHASE I:Develop a diagnostic concept that provides an improved hardware or measurement capability. Produce a detailed design for an experimental instrument or algorithm based on that concept. Delivery of prototype is encouraged.

PHASE II:Based on the Phase I design work: 1) construct or further develop experimental instrument(s) or algorithm(s), and 2) demonstrate the instrumentation or algorithm. Delivery shall include documentation on the operation and maintenance of all delivered hardware and/or software.

PHASE III DUAL USE APPLICATIONS: Industries interested in this work include telecommunications, aviation, and civil Global Positioning System (GPS) manufacturers. SBIR results will be applied to these industries by providing technologies that make space-based communications and space-based navigation more secure and reliable. Anticipated benefits include improved satellite phone reception such as with Iridium or Inmarsat phones, and forecasts of poor GPS satellite reception to commercial airliners which will eventually rely on this technology for landing operations. Within the government, new and improved atmospheric diagnostics have concrete applications for nuclear ban treaty verification and theater missile defense strategies. Diagnosis of the mesosphere is also becoming increasingly important as a means of environmental monitoring for both the military and civilian sectors; such instruments can be effectively applied to expanding initiatives on global change in both the U.S. and abroad. As has happened in the past, new designs for diagnostics of the ionized upper atmosphere may be readily adapted by the plasma fusion community (e.g., incoherent scatter, Langmuir probes, radio-frequency sounding) to investigate laboratory-scale plasma environments.

REFERENCES:

1. Rishbeth, H., Garriott, O., Introduction to Ionospheric Physics. (Chapt.5), NY, Academic Press, 1969.
2. Kelley, M.C., The Earth's Ionosphere, Plasma Physics and Electrodynamics., San Diego, Academic Press, 1989, App. B.
3. Groves, K.M., et al, "Equatorial scintillation and systems support", Radio Science, Volume 32, Number 5, Pages 2047-2064, September-October 1997.

KEYWORDS: ionosphere, telescience, environmental monitoring, ionospheric scintillation, radio-frequency propagation

AF99-068 TITLE: Power Distribution Architectures for Miniature Spacecraft

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop smart power architectures with high efficiency, robustness, and flexibility for miniature and micro-satellite applications.

DESCRIPTION: Improved power distribution and management architectures are needed in small satellites. These systems need robustness to deal with space radiation and thermal environments. High efficiency is also needed, as power in space systems is a precious commodity. Efficiency is a great concern in low-voltage designs, due to loss of headroom in the power conversion electronics and the increased impact on switching and rectification losses. Finally, smart power systems with improved flexibility are needed. Presently, every change in input voltage range, output voltage range, or load conditions promotes a new convertor design. New solutions are needed to create smarter power convertors, allowing one or a small family of convertors to support a wider range of requirements. Standardized distribution manifolds for power as integrated in a structural panel is another intriguing possibility, if it can be shown to be sufficiently flexible for a wide range of satellite bus and payload applications.

PHASE I: Define particular promising concepts and conduct bench-top demonstrations, electrical simulations, and/or other types of demonstrations, with a convincing plan for integration of these concepts into a suitable form for Phase II.

PHASE II:Demonstrate power concepts in a flight-like configuration, possibly in a manner suitable for direct use in space experiments.

PHASE III DUAL USE APPLICATIONS: Power management and distribution approaches are central to complex electronics platforms. While residential power distribution concepts have been in existence for nearly a century, and some power standards exist in automobile and aircraft platforms, the point-of-load end of the power chain is in many cases fairly rudimentary. Smart power and improved standard distribution manifolds and architectures would greatly improve certain platform concepts in the commercial as well as military world, including ship, automobile, and aircraft.

REFERENCES:

1. Microengineering Technology for Space Systems, Aerospace Report No. ATR-95(8168)-2, 30 Sep 95, edited by Henry Helvajian.

2. "Distributed Power Architectures Enter the Mainstream," Lars Thorsell, Electronics Design, 3 November 1997.

3. "Low Profile DC-DC Power Converter for 3-D Electronics Assembly," C. S. Korman, et al., Proc. of the AIAA/IEEE 15th Digital Avionics Systems Conference (DASC), Atlanta, GA, October 27-31, 1996, (IEEE Press Inc., Piscataway, NJ), vol. A96-45660, 1996.

KEYWORDS: power electronics, dc-dc power conversions, late-point configuration, point-of-load conversions, distributed power architectures, power management and distribution

AF99-069 TITLE: Innovative Measurement Techniques for Space-Based Remote Sensing/Standoff Detection

TECHNOLOGY AREA: Battlespace Environments

OBJECTIVE: Develop optical techniques for optimizing target-to-background contrast and identification/ quantification of materials and atmospheric constituents/effluents.

DESCRIPTION: The Air Force Research Laboratory's Battlespace Environment Division (AFRL/VSB) is interested in innovative techniques and approaches which leverage recent progress in commercial technology to characterize the optical properties of the environment, to optimize target detection, search, and track capabilities in structured environments, to identify materials, and to identify and quantify atmospheric constituents/effluents. Examples include passive optical techniques which collect spectral, spatial and temporal data. Many commercial technologies are emerging that could be developed into innovative measurement technologies. The focus of the efforts will be directed toward space-based applications.

PHASE I: Conduct analyses comparing candidate data collection and analysis approaches to current technologies with respect to sensitivity, spectral and/or spatial resolution, temporal resolution, etc. New data collection and data processing methodologies will be defined and assessed in terms of target-to-background contrast enhancement and/or clutter suppression, as well as for accuracy and speed. Explore techniques to identify materials and to identify and quantify atmospheric constituents/effluents. Investigate ways in which new technologies could be applied to other military and commercial applications.

PHASE II:Conduct tests to determine how effectively the proposed techniques address the requirements of the intended application(s). Develop an automated, near-real-time, data processing system, and demonstrate this system using synthetic and real data.

PHASE III DUAL-USE APPLICATIONS: The techniques and methodologies developed under this effort potentially will be useful in military systems requiring autonomous threat recognition and identification under stressing conditions of cloud and haze cover, sensor clutter induced by scene structure, as well as for the identification of materials, and the identification and quantification of atmospheric constituents/effluents. Potentially it will be useful also for non-military applications involving target/species recognition under stressing real-world conditions of scene-induced clutter/noise and spectral interference.

REFERENCES:

1. "Infrared spaceborne remote sensing III", Proceedings of the SPIE Meeting, San Diego, CA, July 12-14, 1995, M. S. Scholl and B. F. Andresen, eds.

2. Target detection in desert backgrounds - Infrared hyperspectral measurements and analysis, M. T. Eismann et al, in "Signal and data processing of small targets", Proceedings of the SPIE Meeting, San Diego, CA, July 11-13, 1995, Vol. 2561, 1995, pages 80-97.

3. Atmospheric correction of hyperspectral data in terms of the determination of plant parameters, H. Bake and W. Mauser in "Recent advances in remote sensing and hyperspectral remote sensing"; Proceedings of the SPIE Conference, Rome, Italy, Sept. 27-29, 1994, Vol. 2318, 1994, pages 52-62.
4. Use of hyperspectral imagery for broad-area detection of small targets, W. F. Kailey in "Imaging spectrometry II", Proceedings of the SPIE Meeting, Denver, CO, 7-8 Aug 1996, Vol. 2819, 1996, pages 15-23.
5. Application of hyperspectral imaging spectrometer systems to industrial inspection, C. T. Willoughby et al, in "Three-dimensional and unconventional imaging for industrial inspection and metrology; Proceedings of the SPIE Meeting, Philadelphia, PA, Oct. 23-25, 1995, Vol. 2599, 1996, pages 264-272.

KEYWORDS: data analysis, hyperspectral, ultraspectral, multispectral, remote imaging, remote sensing, data processing, data acquisition, target detection, spectral signatures

AF99-070 TITLE: Thin Film Flexible, Li-Based Batteries for Space

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Demonstrate feasibility of thin-film, flexible, lithium batteries with sufficient cycle life, capacity, and low temperature operation for LEO space applications.

DESCRIPTION: In space batteries, there is a significant push toward designing and producing lighter, more robust, higher energy density batteries. One trend in satellite design is toward constellations of low power, lightweight, collaborating smallsats that work together to perform a specific mission. For smallsat applications, the energy storage subsystem must be very light and capable of minimizing its mass while meeting the power needs of the spacecraft. One way of addressing these needs is by examining the feasibility of thin film, flexible, lithium batteries with either solid or gelled electrolytes. Due to reduced liquid, both types of electrolytes have distinct mass advantages over cells with conventional liquid electrolytes. Even for gelled polymers, which contain some liquid, the amount of liquid electrolyte is greatly reduced. The Air Force is interested in thin film, flexible, Li-based batteries that could be employed in a wide variety of configurations such as large arrays and/or cylinders, or could be conformed to the shape of and attached directly to spacecraft components. At the battery level, developed concepts should be at least 100 W-hr/kg and be capable of operating at less than 25 degrees C for 5000 cycles.

PHASE I: Investigate potential chemistries for thin film, flexible cells. Demonstrate feasibility of several concepts with small area cells and a small number of cycles.

PHASE II:Initial optimization of chemistries identified in Phase I. Downselect to most promising concept and perform detailed optimization. Place several cells in several configurations on life cycle test with LEO mission profile. Identify industry partners interested in producing and commercializing final product.

PHASE III DUAL USE APPLICATIONS: A large market exists for thin film battery technology both in space and terrestrially. Many LEO communications satellite systems are currently being flown, and a lightweight, large capacity, thin film battery would be very useful for increasing the capability of these satellites for military and commercial applications. Terrestrially, these batteries could enable next generation laptop computers and other electronic components, which is a large, sustainable market.

REFERENCES:
1. Doddapaneni, N., Nagasubramanian, G., and Ingersoll, D., 1995, "Solid-State Rechargeable Lithium Batteries for Electric Vehicle Applications," Handbook of Solid State Batteries & Capacitors, M.Z.A. Munshi, ed., World Scientific, New Jersey, pp. 371-392.
2. Koksbang, R., Olsen, I., and Shackle, D., 1994, "Review of hybrid polymer electrolytes and rechargeable lithium batteries," Solid State Ionics, Vol. 69, pp. 320-335.

KEYWORDS: thin film, space power, lithium ion, energy storage, secondary battery, polymer electrolyte

AF99-071 TITLE: Latching Microrelays in Thin Plastic Material Systems

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop latching microrelays and microswitches that are compatible with Multi-Functional Structure (MFS) substrate materials.

DESCRIPTION: The global need is to develop a latching switch that can be fabricated directly in high density packaging materials. The Air Force problem is to decrease the mass and volume of switches used in space systems, and to make these switches compatible with proposed microsatellite system bus architectures, specifically the Multi-Functional Structure system (MFS) in which interconnect wiring is formed directly in a laminated plastic substrate which also functions as the spacecraft structure. Latching relays fabricated directly in the MFS substrate will increase the flexibility of microsatellite design. Beyond the usual power routing and overload protection tasks, this embedded switching capability will make it possible for the system to reconfigure itself when hardware fails, or to switch in backup systems. Numerous high fidelity DC-capable switches will make the multifunctional substrate more flexible at the design stage by allowing a more generic architecture to be manufactured in volume, then customized for the specific hardware mounted on it by setting the switches properly. This re-routing capability will also enable on-orbit robotic repair of electrical systems, or will add new modules to an existing system. Acceptable approaches would employ some form of actuator change the state of the switch, which does not require power after state change. To meet Air Force needs, each switch should consume no more than 100 mW of power for no more than 500 milliseconds when changing states, and must be completely unpowered when in the final state. Each individual switch should be capable of carrying 1 ampere at 5 volts, and should have a standoff voltage TBD above 3,000V when the contacts are open. Switches should employ industry standard metalization for reliable contacts. Switches should fit within an area of approximately 2 x 0.25 cm. The switch must have at least 2 stable positions, and the design should be flexible enough to allow a single actuator to throw multiple contacts, i.e. a multi-pole, double-throw switch. Switches must be fabricated directly in the MFS material system, the main component of which is the laminated Kapton plastic sheets. Actuators must operate in the natural space environment within a TBD temperature range. Contact resistance for a single closed contact should not exceed 0.1 ohms. The actuation circuitry must be isolated from the signal path being switched.

PHASE I:Establish the viability of the actuation mechanism, and develop the fabrication techniques for the actuator(s). Outline the possible latching switch architectures. Concept demonstration can consist of an final-sized actuator moving a mockup switch between the two stable states, with or without final metalization. Establish a clear path for full fabrication.

PHASE II:Finalize development of Phase I switch design, with a clear path toward making the device manufacturable in large quantities. Concept demonstration will be an array of 32 switches making reliable low resistance (less than 0.1 ohm) connections for each of 100,000,000 cycles.

PHASE III DUAL USE APPLICATIONS: The military, as well as commercial space industry, will benefit from this technology which reduces mass and volume of switches in space systems while increasing flexibility. These switches will be compatible with overlay-style high density electronic packaging, and as such will find a market in the mobile communications area as well as portable electronic test hardware.

REFERENCES:
1. J. Butler, V. Bright, and J. Comtois "Advanced multi-chip module packaging of microelectromechanical systems," Tech. Digest of the 9th International Conference on Solid-State Sensors and Actuators (Transducers '97), Vol. 1, pp. 134-144, July 1997.
2. J. Butler, V. Bright, R. Saia, and J. Comtois, "Extension of high density interconnect multichip module technology for MEMs packaging," Proc. SPIE, Vol. 3224, Micromachined Devices and Components III, pp. 169-177, September 1997.
3. Vollmer A., " 0.1-MM Eectrostatic Microrelays Switch at up to 100 GHZ", Electronic Design, v. 45(#27) pp. 34-34 Dec 1, 1997.
4. Hiltmann K, Ashauer M., Sandmaier H., Lang W. "Silicon Thermal Microrelays with Multiple Switching States," v. 62(#1-3) pp. 612-615 Jul 1997.
5. Tonnesen T., Ludtke O., Noetzel J, Binder J, Mader G, "Simulation, Design And Fabrication Of Electroplated Acceleration Switches," Journal Of Micromechanics And Microengineering, V. 7(#3) Pp. 237-239 Sep 1997.

KEYWORDS: MEMS, Kapton, electronics, mesomachines, latching microrelay, contact metalization

AF99-072 TITLE: Integrated Power Cell

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop a thin, flexible, lightweight integrated satellite electric power system using thin film solar cell, thin film battery, and lightweight power electronics technologies.

DESCRIPTION: The combination of thin-film solar cells, thin-film batteries, and miniaturized control electronics into an integrated system is called the integrated power cell (IPC). This combination of power subsystems provides a cost effective and highly modular power system. IPCs interconnect with one another to provide a complete power system with minimal exterior design and configuration. The development of this technology will build on recent progress made toward development of thin film batteries, thin film solar cells, and miniaturized power electronics. One challenging aspect of the IPC will be the integration of the battery with the other components, where the battery is typically intolerant to wide temperature variations. The final result is a very high specific energy density (>15 W/kg) and reduced $/W standard electric power system product that can be ordered with a variety of solar cells, batteries, and electronics.

PHASE I: Design suitable technical approaches needed to enable integration of thin-film solar cell, battery, and electronics functions. Identify a suitable flexible substrate, flexible microbattery device, low temperature thin-film solar cell, and power management and control electronics architectures.

PHASE II:Phase II will focus on scaleup issues which include the flexible IPC product configuration, sizing of the final IPC array, and first-order cost modeling.

PHASE III DUAL USE APPLICATIONS: Dual-use commercial potential is excellent for small and medium-sized commercial satellites, where the goal for the IPC of >15 W/kg is a factor of 3X greater than current commercial SOTA systems.

REFERENCES:
1. "Thin Onboard Power Storage for Photovoltaics (TOPS-PV)", final report PL-TR-95-1149, Joseph Armstrong, ITN Energy Systems, Oct. 95.
2. "Current Status of Polycrystalline Thin-Film PV Technologies", H.S. Ullal, K. Zweibel and B.G. von Roedern, National Energy Laboratory Report NREL/CP-520-22922, Sep. 1997.

KEYWORDS: solar cells, pace power, power storage, energy storage, integrated power, power management, energy generation

AF99-073 TITLE: Advanced Algorithms for Exploitation of Space-Based Imagery

TECHNOLOGY AREA: Battlespace Environments

OBJECTIVE: Develop algorithms to optimize detection, identification and tracking of targets for materials identification and for identification/quantification of atmospheric constituents/effluents.

DESCRIPTION: The Air Force Research Laboratory's Background Clutter Mitigation Branch (AFRL/VSBM) is interested in innovative techniques for the mitigation of clutter effects in an effective and computationally efficient manner for optimum search, detection, and tracking performance of space-based optical (ultraviolet/visible/infrared) systems. Mitigation requires advanced algorithms based upon spatial, temporal, and spectral techniques. Data from space-based missions has led to a data base of optical data (ultraviolet, visible, and infrared) to characterize the optical properties of the environment which could be exploited to explore potential space-based detection techniques for clutter-mitigation/contrast-enhancement techniques to optimize target detection, to identify materials and to identify and quantify atmospheric constituents/effluents. While many (individual) techniques exist, many have not been properly evaluated for optimum utility at the systems level, nor have they been systematically combined to assess the potential benefits of concatenating algorithms to improve detection probabilities/reduce false-alarm rates.

PHASE I: Conduct analyses, using real data, to identify the classes of algorithms for clutter-mitigation/contrast-enhancement techniques to: 1) optimize target detection, search, and track capabilities in structured environments, 2) identify materials, and 3) identify and quantify atmospheric constituents/effluents. Compare and contrast the candidate algorithms. Provide a suite of preliminary algorithms suitable for testing with experimental and simulated data.

PHASE II:Perform detailed analyses and demonstrate the efficacy of algorithms for: 1) target detection, search, and track in structured environments, 2) materials identification, and 3) identification and quantification of atmospheric constituents/effluents. Conduct tests, as required, to assess the effectiveness of the algorithms. Develop and demonstrate an automated, near-real-time processing system using real-world data sets.

PHASE III DUAL-USE APPLICATIONS: The algorithms and processing techniques developed under this effort potentially will be useful in military systems requiring autonomous stand-off detection under stressing conditions of sensor clutter induced by scene structure and the data-collection process, and spectral interferences. It potentially will also be useful for non-military applications involving autonomous detection under similar conditions of scene-induced and sensor-induced clutter and noise and spectral interferences.

REFERENCES:
1 . Algorithms for multispectral and hyperspectral imagery, SPIE Conference Proceedings, Orlando, FL, Apr 1994, A. E. Iverson, ed.
2. Thermal imagery spectral analysis, B.H. Collins et al., Proceedings of the SPIE Meeting, San Diego, CA, 28-30 Jul 1997, "Imaging spectrometry III", pages 94-105.

3. Target detection in a forest environment using spectral imagery, R. C. Olsen et al., Proceedings of the SPIE Meeting, San Diego, CA, 28 -30 Jul 1997, "Imaging Spectrometry III", pages 46-56.
4. Unsupervised interference rejection approach to target detection and classification for hyperspectral imagery, C. Chang et al., Opt. Eng. 37 (3) 735 (Mar 98).
5. Targeting and intelligence electro-optical recognition modeling: a juxtaposition of the probabilities of discrimination and the general image quality equation, R. G. Driggers et al., Opt. Eng. 37 (3) 789 (Mar 98).

KEYWORDS: imaging, algorithms, non-imaging, data analysis, hyperspectral, ultraspectral, multispectral, data processing

AF99-074 TITLE: Satellite Local Area Network (LAN)

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop and demonstrate architectures, concepts, and hardware for satellite local area data networks.

DESCRIPTION: Trends towards less costly approaches to meet mission requirements have generated new architectures for space systems. One such novel concept is the idea of collaborating clusters, or swarms, of small satellites flying in close formation working cooperatively to do the job of a larger, more complex satellite. Notional missions for these clusters include radar, communications, navigation, and passive radiometry. To effectively perform a complex mission, the small satellites must maintain relative autonomy (attitude and control correction) and share/distribute processing capabilities. A network will be developed that best utilizes existing technologies/hardware (both current-off-the-shelf and developmental). The crosslink (either pulsed or continuous) will be required to connect four to sixteen satellites at close range (less than one kilometer) and satellite clusters at long range (greater than one kilometer). Realize that the arrangement of the satellites is dictated by mission needs, and one satellite may obstruct the line-of-sight of two other satellites. Each satellite will need to communicate with other satellites within the cluster uniquely. The crosslink should be capable of omnidirectional, simultaneous, high data rate communication and be lightweight (under 0.5 kg), low power (less than 1 W), and space survivable (10 years in LEO) for use on a small satellite. The crosslink should also be capable of secure communications either through spread spectrum, frequency hopping, or encryption. The small satellites must be able to effectively communicate at high data rates, up to 250 Mbps, with low bit error rates, less than 1E-6, over a kilometer range and permit the satellites to know their relative positions within an SEP of a foot. Furthermore, the crosslink should not interfere with any mission of the small satellites. One mission of these devices may be an X-band distributed aperture radar. There are several commercial terrestrial versions of similar devices, for computer wireless LANs, that use radio transmitters and receivers and a conventional ethernet protocol (such as TCP/IP). A similar device suitable for spaceborne applications is desired.

PHASE I: Explore concepts and technologies for satellite LAN architectures. Analyze and trade design parameters defining the hardware, software, and operations requirement. Select concepts for more detailed evaluation. Where appropriate, validate key technology concepts by analysis or modeling the architecture or limited component testing and assess the feasibility.

PHASE II:Develop a proof-of-concept prototype. Fabricate and test components by communicating between several systems.

PHASE III DUAL USE APPLICATIONS: The technologies developed here could be implemented in laptop personal computers, fleets of ships or trucks, and commercial LEO communications satellites. Lightweight wireless LANs developed under this SBIR, with about 100 times the speed of commercially available LANs, could be competitive in high-end laptop systems. Availability of these technologies for large military (as well as possible commercial) LEO constellations could also provide cost and weight effective crosslinks for these systems.

REFERENCES:
1. D. Bantz, "Wireless LAN Design Alternatives," IEEE Network, March/April 1994, pp. 43-53.
2. B. Jabbari, et al, "Network Issues for Wireless Communications," IEEE Communications Magazine, January 1995, pp. 88-98.
3. H. Ahmadi, A. Krishna, and R. O. Lamaire, "Design Issues in Wireless LANs," Journal of High Speed Networks, Vol. 5, 1996, pp. 87-104.
4. Wireless Network References - http://www.cis.ohio-state.edu/~jain/refs/wir_refs.htm
5. Satellite Communications References - http://www.cis.ohio-state.edu/~jain/refs/sat_refs.htm

KEYWORDS: network, crosslink, lightweight, high data rate, data transmission, miniature hardware, space communications

AF99-075 TITLE: Development of an Integrated Autonomous Optical Imaging Polarimeter-on-a-Chip

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a compact intelligent optical imaging polarimeter on a chip that automatically detects and processes optical radiation to determine its polarization state and interpret the result.

DESCRIPTION: The surveillance missions of satellites, satellite constellations and other unmanned space vehicles, requires the development of intelligent optical sensing systems that can detect and interpret optical signals autonomously. Intelligent sensing systems combine the detection processing and control functions of complete optical systems onto a single package such as a focal plane, detector chip or multichip module. One promising application of intelligent optical systems for autonomous satellites is in the detection, processing, and evaluation of polarization imagery. Imagery from the polarization properties of passive radiation emitted and reflected in the short wave, mid-wave and long wave IR has shown potential for improved target discrimination over other IR imaging techniques. (Ref.'s 1-2)

The polarization state of an electromagnetic wave is fully described by a set of four parameters known as the Stokes parameters.(Ref.'s 3-5) Collectively, these parameters comprise the Stokes vector and represent the magnitudes of the unpolarized component, two different linear polarized components, and the circularly polarized component of the radiation. It is the relations between these four parameters that can act as tools for the discrimination of military targets in IR imagery. (Ref.'s 6-10)

Development of an integrated optical imaging polarimeter requires consideration of optical polarization detection hardware in which the polarization state at each pixel in an image is determined. In combination with the polarization state, processing circuitry must be developed to detect anomalous or prescribed polarization signals. To be useful in space applications, systems developed in this program must detect and process polarization information autonomously. Optical and electronic components should be simple and compact, and processing algorithms should be suitable for implementation in onboard processors. Integration of polarization optics and processing circuitry components onto the detector plane is desirable. (Ref.'s 11-13) Exploiting polarization at multiple wavelengths and combining this information with spectral signatures is the logical extension of this autonomous polarimeter chip development program.

PHASE I: Explore concepts and technologies for the design of an intelligent optical imaging polarimeter on a chip. Identify optical detection scheme, polarization processing for determing complete polarization state at each pixel, and concepts for processing to interpret anomalous polarization signal from within a single pixel or from groups or clusters of pixels. Also identify system control and packaging concepts for complete system autonomy. Establish the feasibility of the approach.

PHASE II:Develop a system prototype that demonstrates autonomous imaging polarization detection and processing. Determine and validate key performance metrics.

PHASE III DUAL USE APPLICATIONS: Polarimeter-on-a chip concepts have applications in improved automatic target detection and identification systems in unmanned space surveillance platforms. Technologies developed in this project would be useful for passively detecting potential targets in a wide field of view and cueing an active target designator or other surveillance systems. Technologies developed for this program can also be employed in machine vision and automated non-destructive testing applications.

REFERENCES:

1. F. Sadjadi, C. Chun, "Improved feature classification by means of a polarimetric IR imaging sensor," IGARSS '96, 1996 IEEE International Geoscience and Remote Sensing Symposium, Vol. 1, ed. T. I. Stein, p. 396-401.

2. Y. Ito and S. Omatu,"Polarimetric SAR data classification using scattering models and nueral networks," European Symposium on AerospaceRemote Sensing, 22-26 Sep 1997 (London, UK)
poster presentation 3217-20.

3. Russell A. Chipman, "Polarimetry," Chapter 22 in the Handbook of Optics (McGraw-Hill, New York, 1997).

4. O. Sandus, "A review of emission polarization," Applied Optics 4 (12), December 1965, 1634-1642.

5. R. W. Collins, "Automatic rotating element ellipsometers: calibration, operation and real time applications," Review of Scientific Instruments 61(8), August 1990, 2029-2062.

KEYWORDS: polarimetry, smart pixels, multichip modules, focal plane arrays, on-board processing, automatic target recognition

AF99-078 TITLE: Self-Aligning High Density Connectors

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop extremely high density electrical connectors that are small and easy to use.

DESCRIPTION: The global need is to develop a connector system that increases the number of contacts that can be made in a given area, as well as eliminating the increased insertion force that typically accompanies an increased number of contacts. The Air Force problem is to decrease the mass and volume of connectors used in space systems, and to accommodate more connections with smaller, lighter hardware. A self-aligning system will not only enable more contacts per area than is possible with current manually aligned connectors, but may also enable future systems for on-orbit robotic repair of electrical systems. Acceptable approaches would employ some form of actuator to align the contact pins as well as to grip the two halves of the connector system together. One approach may be to use shape memory alloy which holds one shape when heated electrically, and another when unpowered. A two-stage approach to alignment may also be necessary, with rough alignment via tapered pins, and final alignment with some active pin-positioning system. The contact pins may be aligned as a whole, as long as the pin-to-pin spacing on both halves of the connector are held rigidly. To meet Air Force needs, the connector system can consume up to 4 watts of power for no more than 5 seconds when engaging, but must be completely unpowered when in the connected or disconnected state. The connector halves must be mechanically interlocked when engaged and unpowered, with no further manual tightening needed. The person making the connection should merely have to bring the two halves together with zero insertion force, and the automatic system should take over for contact pin alignment and mechanical joining of the two connector halves. The pin-to-pin spacing should be no more than 10 mils, with smaller spacing desirable. The design should allow for multiple rows of contact pins and should include a method of bringing the wiring from the cable to the contact pins of the connector.

PHASE I: Prove the viability of the actuation mechanism and develop the fabrication techniques for the actuator(s). Outline the possible connector architecture and methods to be used to ensure contact alignment and mechanical interlock. Concept demonstration can consist of an final-sized actuator moving a mockup contact pin and locking the two connector halves together.

PHASE II:Develop a self-aligned connector system as outlined above, with a clear path toward making the device manufacturable in large quantities. Concept demonstration will be a final connector design with more than 128 contacts making reliable low resistance (less than 0.1 ohm) connections for each of 20 cycles.

PHASE III DUAL USE APPLICATIONS: High density connectors will find a ready commercial market in the growing complexity of computer systems, especially small portable systems with detachable peripherals. Benefits are increased peripheral functionality with decreased dexterity requirements on the part of the consumer. A typical application may be the increasingly popular Personal Digital Assistants (PDAs) which are typically shirt pocket-sized, yet are taking on more functions found in full-sized personal computers.

REFERENCES:

1. Lyke, J., "Packaging technologies for space based microsystems and their elements" in Microengineering Technology for Space Systems (H. Helvajian, ed.), The Aerospace Corp. Report No. ATR-95(8618)-2, pp. 131-180, 30 September 1995.
2. Hiltmann K., Ashauer M., Sandmaier H., Lang W. "Silicon Thermal Microrelays With Multiple Switching States," Sensors And Actuators A-Physical, V. 62(#1-3) Pp. 612-615 Jul 1997.
Tonnesen T., Ludtke O., Noetzel J., Binder J., Mader G., "Simulation, Design And Fabrication Of Electroplated Acceleration Switches," Journal Of Micromechanics And Microengineering, V. 7(#3) Pp. 237-239 Sep 1997.
3. Lucas S., Kission K., Pinel J., Bonnaud O., "Polysilicon Cantilever Beam Using Surface Micromachining Technology For Application In Microswitches," Journal Of Micromechanics And Microengineering, V. 7(#3) Pp. 159-161 Sep 1997.
4. Ren H., Gerhard E., "Design And Fabrication Of A Current-Pulse-Excited Bistable Magnetic Microactuator," Sensors And Actuators A-Physical, V. 58(#3) Pp. 259-264 Mar 1997.
5. Majumder S., Mcgruer N. E., Zavracky P. M. , "Electrostatically Actuated Micromechanical Switches," Journal Of Vacuum Science & Technology A-Vacuum Surfaces And Films, V. 15(#3/Pt.2) Pp. 1246-1249 May-Jun 1997.

KEYWORDS: electronics, microcontacts, microactuators, active alignment, zero-insertion-force, lectrical connectors

AF99-079 TITLE: Micro Alignment Manipulator Architectures (MAMAs)

TECHNOLOGY AREA: Electronics

OBJECTIVE: Integrate Vertical Cavity Surface Emitting Lasers (VCSELs) with Micro Electro Mechanical Systems (MEMs) to produce active alignment architectures for optical fibers or other optical elements.

DESCRIPTION: High speed data transfer in the near and far term poses limitations when using copper or metal-based media. Photonics technology has overcome many of the problems associated with wire-based data transfer. Optical information exchange via the use of high speed lasers, modulators, and fiber optics will continue to play a greater role in managing this ever-increasing data congestion. The introduction of Vertical Cavity Surface Emitting Lasers (VCSELs) offers promise in alleviating these problems. The issue to be addressed in this topic is a need for active alignment of multiple optical fibers to VCSEL or detector arrays.

With advancements in the produceability of Micro Electro Mechanical systems (MEMs), it is projected that the geometry of VCSELs and MEMs could be integrated to form robust optical interconnects for use with singlemode optical fibers or free space board-to-board communications. Currently, the methods for aligning and fixing optical fibers to small active regions of laser diodes or detectors is economical for cases where only several fibers are being coupled. With an increasing number of active elements to be aligned, the issues become technically challenging and costly.

The primary issue is the thermal stability of the alignment structure and how dimensional expansion/contraction affects the ultimate alignment of multiple elements. This dimensional instability problem increases greatly when the fiber being aligned is of the singlemode type. Singlemode fibers typically have core sizes between 5 and 10 microns, which makes the alignment of multiple sites difficult when considering the dimensional thermal instability of a much larger alignment fixture to an active array of emitters or detectors The advantages of singlemode fiber over larger core multimode are many, but in general offer much higher bandwidth which is needed to meet the increasing data volume and transfer rates of future information systems.

The ideas envisioned for the integration of MEMs with VCSELs include active alignment of either fibers, mirrors or lenses to active emitters and detectors. The feasibility of incorporating all on a single substrate poses serious technical challenges. However, the idea of a MEM structure physically translating an optical fiber over several microns offers the packaging community advantages over current methods. Another advantage of the MEMs alignment method is the ability to scale to much larger multi-element configurations. Micro Alignment Manipulator Architectures (MAMAs) offer a solution to the packaging community to economically produce high speed parallel optical networking systems.

PHASE I: 1) Investigate the feasibility of a MEM device to physically manipulate the alignment of an optical fiber to an active VCSEL. 2) Develop a MEMs design that would be capable of performing an active alignment task between a single element VCSEL and a single optical fiber. 3) Fabricate and demonstrate the 1-D design. 4) Recommend a 2-D design for active alignment of multiple elements.

PHASE II:Fabricate and demonstrate the 2-D design recommendation from Phase I.

PHASE III DUAL USE APPLICATIONS: Implement the Micro Alignment Manipulator Architectures to commercial and military products needing active alignment of micron-sized elements.

REFERENCES:

1. E.W. Taylor, A. H. Paxton, H. Schone, J. Comtois, A. D. Sanchez, A. Michaleick, J. E. Winter, S. J. McKinney, R. Carson, M. Osinski, P. Perlin, J. Bristow, J. Lehman, M. Hibbs-Brenner, (Invited Paper), "Radiation Induced Effects Research in Emerging Photonic Technologies: VCSELs, GaN LEDs and MEMs Devices", Proc. Int. Soc. Opt. Engr., Vol. 3124, Aug 1997.

2. H. Helvajian, S. W. Janson, E. Y. Robinson, "Big Benefits From tiny Technologies: Micro-nano-technology Application in Future Space Systems", Chapter 1, published in SPIE Critical Reviews book: Advancement of Photonics For Space, Vol. CR 66, July 1997.

3. E. W. Taylor, (Invited Paper)"Advancement of Radiation Effects Research in Photonic Technologies for Application to Space Platforms and Systems", Chapter 3, published in SPIE Critical Reviews book: Advancement of Photonics For Space, Vol. CR 66, July 1997.

KEYWORDS: MEMs, VCSELs, optical fiber, communications, active alignment, data transmission

AF99-082 TITLE: Training for Space Operators Using a Distributed Mission Training Environment

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Provide Distributive Mission Training capabilities to support the warfighters and space operators in performing their mission more efficiently and effectively.

DESCRIPTION: Develop a Distributed Mission Training environment through simulation technology to enhance the training of space operators and warfighters. The phased approach will provide a complete assessment and evaluation of the advanced simulation and training requirements needed to accommodate team distributed training for space operators and warfighers. The identification of potential technology improvements capable of accommodating the advanced training for AFSPC operators and warfighters is essential for developing and refining the requirements for virtual, live, and constructive modeling and simulation for the DMT environment. With a fully capable environment for implementing DMT, new technologies will be designed and developed for a distributed mission training testbed for team training. Assessment and evaluation of the DMT testbed will validate the mission training technology applications.

PHASE I: Phase I will result in a proposed proof-of-concept technology to support team distributed training for space operators and warfighters. Assessment and evaluation data for advanced simulation technologies will enhance mission objectives of space training directly related to mission, training tasks, team participants, combat tasks, adversaries, and theater procedures. Task measurements for assessing space operator and warfighter team training integration include those related to training in combat and the evaluation of mission preparedness. Two domains will be assessed for testing. One domain will be space related specific to the military team environment such as mission planning. One will be related to a non-military domain such as NASA or to a commercial enterprise such as regional sales teams or product development teams.

PHASE II: Phase II will fully develop, refine, test and evaluate the requirements for virtual, live, and constructive modeling and simulation to support a distributed mission training environment for space operators and warfighters. Additional activities in Phase II include specifications for a demonstration of virtual, live and constructive combat based scenarios in a DMT environment with a space-based operator at one site interacting with warfighter(s) at a separate site. Document analytical evaluation of testbed application of DMT. Document description of simulated data. Proposals should assume that the technology will run in a platform-independent environment.

PHASE III DUAL USE APPLICATIONS: This effort will provide a cost-effective capability to implement high fidelity, multi-role, interactive training and system integration. The results of this effort have high value to the Public Sector as group and team training at distributed sites becomes essential. Phase III Dual Use potential is significant as no other technology exists that provides an intelligent-linked, scenario-driven, performance-based team training capability supporting live, virtual, and constructive events. Applications of this technology are highly innovative and would benefit both the Government and Public Sector to reduce cost-prohibitive development of environments for training and performance assessment.

REFERENCES:
1. AFMC Training System Product Group Distributed Mission Training Homepage: http://tspg.wpafb.af.mil/programs/dmt/default.htm.
2. Burgeson, J.C., et al., (1996). Natural effects in military models and simulations: Part III - Analysis of requirements versus capabilities. Report No., STC-TR-2970, PL-TR-96-2039, (AD-A317 289), 48 p., Aug.
3. Defense Modeling and Simulation Office homepage: www.dmso.mil
4. Distributed interactive simulation systems for simulation and training in the aerospace environment. Proceedings of the Conference, Orlando, Fl, Apr 19-20, 1995. Clarke, T. L., ED. Society of Photo-Optical Instrumentation Engineers (Critical Reviews of Optical Science and Technology, vol. CR 58) 338p.
5. Kolanowski, S. (1997). Background paper on Distributed Mission Training for Space Operations. SMC/XRT, 2430 E. El Segundo Blvd., Suite 340, El Segundo CA 90245-4687.

KEYWORDS: Team Integration, Space Superiority, Intelligent Systems, Performance Measurement, Battlefield Environments, Advanced Simulation Training, Distributed Mission Training

AF99-083 TITLE: Modeling and Simulation of Less Than War Scenarios

TECHNOLOGY AREA: Manpower, Personnel, and Training

OBJECTIVE: Develop a simulation which can measure the ability of alternative force packages to deter combat in an Operations Other Than War (OOTW) scenario.

DESCRIPTION: The evaluation of modernization initiatives in acquisition decision making has centered around modeling and simulation of Major Regional Conflict (MRC). These types of conflict are, for example, representative of the Desert Storm operation. However, there is a high probability that U.S. forces will be involved in OOTW. In the future, systems, which can contribute to the mission of preventing combat, will become increasingly important. It has long been held that weapon systems and technologies that successfully compete at the higher levels of war will be able to treat the "less-than-war" situations. Alternatively, there is a view that systems, which can deal with the problem of peacekeeping and deterrence, might not show a lot of promise at the MRC level of conflict. Whereas, major regional conflicts primarily deal with participant's kills/losses and territory gained or lost, OOTW deal with different metrics and objectives such as time delays, efficiency, or controlling a situation. Methodologies and software are needed to quickly build and assess the outcome of OOTW scenarios in order to evaluate promising technologies, systems and tactics.

PHASE I: Develop a prototype methodology/software and perform a feasibility demonstration for modeling OOTW.

PHASE II:Extend prototype into a fully functional OOTW simulation, and apply the simulation in historical and future scenarios.

PHASE III DUAL USE APPLICATIONS: High commercial applicability in the areas of military planning, drug, immigration, and law enforcement. The vendor will be able to market software to both government and civilian commercial companies. Government agencies will include federal, such as Department of Defense (DoD), as well as state and local governments.

REFERENCES:

JP 3-07 Joint Doctrine for Military Operations Other Than War, 16 June 1995
url: http://www.dtic.mil/doctrine/jel/new_pubs/jp3_07.pdf

KEYWORDS: Deterrence, Simulation, Peacekeeping, Alternative Force, Operations other than War

AF99-084 TITLE: Next Generation Distributed Joint Aircrew Training Effectiveness

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Develop innovative evaluation models and tools for Air Force instructors to use for interactively evaluating Joint Distributed Mission Training, wargaming analysis, training evaluation feedback, etc.

DESCRIPTION: Research computer algorithms, including object-oriented technologies, which will apply training information provided by various Aircrew training courses, Joint Distributed Mission Training simulations, wargame exercises, etc. to aid decisions concerning how training results can be used in training forecast models. Identify the information required from training exercises, simulations, and simulators for input to evaluation algorithms that measure aircrew and team performance in either flight simulators or actual flying training. Identify or develop innovative tools, methods, and metrics, which support training evaluation and analysis, creation or linking of course instruction to domain analysis, and developing repositories for training effectiveness data reuse. Research cost-effective ways to link live flight training and flight test analysis data in order to develop and validate flight simulator training. Unique and innovative applications of existing commercial tools will be considered.

PHASE I: Describe the proposed new concepts in detail, including a description of their viability and feasibility and recommendations regarding which appear most promising.

PHASE II: Develop and demonstrate a working prototype tool or software program. Evaluate the tool or program and document the evaluation effort in a report.

PHASE III DUAL USE APPLICATIONS: All solutions must have potential for dual-use/application in the commercial as well as military sector. Potential commercial applications must be identified and discussed in the proposal.

REFERENCES:

1. AFMC Training System Product Group Distributed Mission Training Homepage: http://tspg.wpafb.af.mil/programs/dmt/default.htm
2. Bowers, C. A., Baker, D. P., & Salas, E. (1994). Measuring the importance of teamwork: The reliability and validity of job/task analysis indices for team-training design. Military Psychology, 6, 205-214.
3. Burgeson, J. C., et al. (1996). Natural effects in military models and simulations: Part III - Analysis of requirements versus capabilities. Report No. STC-TR-2970, PL-TR-96-2039, (AD-A317 289), 48 p., Aug.
4. Defense Modeling and Simulation Office homepage: http://www.dmso.mil
5. Distributed interactive simulation systems for simulation and training in the aerospace environment. Proceedings of the Conference, Orlando, FL, Apr 19-20, 1995. Clarke, T.L., Ed. Society of Photo-Optical Instrumentation Engineers (Critical Reviews of Optical Science and Technology, vol. CR 58) 338p.

KEYWORDS: Aircrew Training, Training Evaluation, Training Development, Distributed Training

AF99-085 TITLE: Low-Cost Collimating Screen Materials for Out-the-Window Simulator Displays

TECHNOLOGY AREA: Manpower, Personnel, and Training

OBJECTIVE: Develop low-cost collimating screen for out-the-window simulator displays.

DESCRIPTION: This topic calls for advances in collimated, rear-projection, flat and/or curved (in one or two dimensions) display screen technology. Screen technology developed under this project will be used in enhanced versions of the Mobile Modular-Based Display for Advanced Research and Training (M2DART) and other applications requiring low-cost collimated displays. The M2DART is a flight simulator visual display developed at the Human Effectiveness Directorate/Warfighter Training Research Division (AFRL/HEA). In its current design, the M2DART uses commercial off the shelf projector technology and eight flat, rear projection screens tiled together to present a 360o wrap-around out-the-window scene. The horizontal field-of-view (FOV) for each of the 8 window screens varies between 72 and 82 degrees. The screen normals are positioned at a 36 inch viewing distance from the design eyepoint. Future enhancements to the M2DART also include high resolution laser based projectors currently under development. Display screens developed under this project must: be low-cost;

be thin (less than 3 inches in thickness); allow for either CRT or laser based rear projection of imagery; enable tiling of multiple screens; have minimal distortion, optical aberration, lune, and ghosting effects; be light weight; have a large exit pupil; and have high transmissivity.

PHASE I: Provide a technical report determining feasibility of the concept and provide a demonstration of the feasibility.

PHASE II:Phase II will result in prototyping and testing display screens proposed under Phase I and a technical report.

PHASE III DUAL USE APPLICATIONS: Commercial training for flight, automobile, and other simulator environments.

REFERENCES:

1. Thomas, M. and Geltmacher, H. (1993, April/May). Combat simulator display development. Information Display, 9, 4 & 5, 23-26.

2. Crane, P.M. (1994). Evaluation of two wide-field-of-view display systems for air combat training. Journal of the Society for Information Display, 2, 1, 59-61.

3. Pierce, B.J. and Geri, G.A. (1997, May). Changes in perceived velocity with viewing distance. Annual Meeting Abstract Issue for Association for Research in Vision and Ophthalmology, 38, 4, 379.

4. Wetzel, P.A., Pierce, B.P., and Geri, G.A., (1996). Effect of viewing distance and oculomotor state on the apparent size of simulator imagery. Journal of the Society for Information Display, 4, 4, 247-253.

KEYWORDS: Projector, Simulator, Collimated, Visual Display, Rear Projection

AF99-086 TITLE: Advanced Controls and Displays for Space Operator Consoles

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop concepts and a testbed for next-generation space operator consoles using multi-sensory display and alternative control technology

DESCRIPTION: Although the Air Force Space Command (AFSPC) has an ongoing series of modernization programs such as REACT (Rapid Execution and Combat Targeting), space operator consoles that support communications, early warning, surveillance, and spacelift operations are in many cases based on outdated control and display technology. Even the modernized consoles do not take advantage of recent advances in multi-sensory displays and alternative controls. Current Air Force Research Laboratory (AFRL) programs have emphasized the application of these technologies to cockpit and aircraft command and control environments. These technologies offer equal payoffs for space operations. The ultimate goal will be to enhance the effectiveness of our "guardians of the high frontier" and to transfer these technologies to a variety of commercial and military aerospace environments.

PHASE I: With the guidance and assistance of AFRL and AFSPC: (1) Identify next generation control and display needs for space operations. (2) Identify candidate space operator consoles or control centers where incorporation of these technologies is likely to produce the highest gains in system effectiveness. (3) Select from these candidates a subset that can be incorporated in a research and technology demonstration testbed in Phase II. Several criteria should guide this selection process. The proposed control and display enhancements should be sufficiently mature to support operational test and evaluation within 5 years of the completion of Phase II. Examples include localized (3-D) audio, haptic (force) guidance and feedback, head-mounted immersive displays, speech recognition, head and eye tracking, and gesture recognition. The functions performed at the selected console(s) should be critical to several elements of space operational effectiveness. To the maximum extent possible, console functions should have elements in common with commercial space, commercial aircraft, and uninhabited aerial vehicle control operations. This will enhance the technology transfer and commercialization aspects of the program. A desired Phase I product is a computer-based rapid prototype that clearly illustrates the consoles(s) chosen for the testbed and the advanced control and display technologies to be incorporated therein. The Phase I report should provide a detailed description of the operator tasks normally accomplished with the console, concepts for integrating the new control and display technology, and an analysis of the anticipated operational payoffs.

PHASE II:Develop a fully functional space console testbed for evaluation and demonstration of the new control and display technologies. It is highly desirable that the testbed be compatible with Distributed Interactive Simulation (DIS) protocols so that it might, in the future, be interlinked with other elements of a DIS network. The Phase II testbed should support the inclusion of space operations models so that mission and operator effectiveness measures can be employed during the Phase II evaluations.

PHASE III DUAL USE APPLICATIONS: The technology developed in this program will be applicable to a wide range of communication and aerospace operator control consoles. Potential application environments include NASA, FAA control centers, commercial space operations, and government and commercial communication control centers. Phase II or III dual-use alliances with these organizations are encouraged and highly likely.

REFERENCES:
1. McMillan, G.R., Eggleston, R.G., and Anderson, T.R., Nonconventional controls, in Salvendy, G., (Ed) Handbook of Human Factors and Ergonomics, 2nd Edition, NY, Wiley, 1997, pp 729-771.
2. Barfield, W., and Furness, T.A., Virtual Environments and Advanced Interface Design, NY, Oxford Univ. Press, 1995.

KEYWORDS: Localized (3-D) Audio, Space Operator Consoles, Multi-Model Interaction, Haptic (force) Guidance

AF99-087 TITLE: Imagery Analyst Interface for Ultra-Spectral Imaging Sensors

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Identify, develop, demonstrate and assess the utility of innovative intelligence imagery analyst-display interfaces, based on visual psychophysics, which are applicable to multispectral imagery.

DESCRIPTION: Human capability for exploiting and analyzing the ever increasing volumes of multi-(and hyper-/ultra-)spectral images is limited. For example, space- and airborne imagery sources are increasing in number without a corresponding increase in the number of human image interpreters. (In fact, there is serious concern regarding the decrease in both the number and experience level of military imagery analysts.) For example, multi-spectral images are increasingly available, but no standard for human viewing of multi-spectral images has yet been developed. Both the military and commercial sectors have made large investments in algorithms for the automated exploitation of multi-spectral imagery. Many of these algorithms employ non-intuitive computations (such as the ratio between pixel intensities in specific wavelength bands or pattern recognition schema employing neural networks). The human analyst is provided with no capability to verify the results of the automation. These problems will only be exacerbated as hyper- and ultra-spectral imaging systems continue to mature. This topic seeks proposals to discover new image display processing and operator interface technologies based on human and biological image processing. Human and other biological systems are known to process images in multiple spectral bands that are held in registration during target recognition and navigation. Further, many of the processing steps of human vision are known and have been formally described, often in terms of algorithms for image processing. This topic encourages the extension of algorithmic descriptions of human multi-spectral image processing to the domain of image display processing. The overall technology objective is a display of (fused and/or otherwise preproceesed) multi-spectral images with measurable advantages for human tasks of interpretation, orientation, and information extraction. Secondary technology objectives include real-time image processing, feature and target segmentation, and wearable, head-mounted, displays. Technology challenges include: (1) spatial registration of multi-spectral static and moving image streams, (2) dynamic range compression or normalization to prevent display saturation, (3) false coloring of fused images for improved human image segmentation and target recognition, (4) benchmark tasks to enable quantitative comparison of various solutions to problems of human image processing performance in recognition and exploitation. For purposes of this topic, multi-spectral is intended to also include polarimetric images within a single spectral band or non-image data that may be fused with image streams.

PHASE I: Produce a proof-of-concept. Identify realistic current and future multispectral imaging sensor system capabilities and operational concepts. Identify and investigate multispectral imagery exploitation tasks and associated information requirements. Develop and implement a proof-of-concept demonstration and assessment plan.

PHASE II:Develop and demonstrate a prototype system capable of operating under realistic conditions of sensor coverage rates, number of electromagnetic spectral regions/bands, fusion and other operator aiding subsystems, and essential elements of information to be satisfied.

PHASE III DUAL USE APPLICATIONS: Military uses of this technology include concealed target detection, materials properties analysis, hydro- and hypsographic analysis, counter-proliferation and counter-terrorist operations. Multispectral sensing has dual use/commercial application in exploration for petroleum and minerals, land-use quantification, crop surveys, law enforcement as well as pollution and environmental monitoring.

REFERENCES:
1. Burman, Jerry A. Nonliteral pattern recognition method for hyperspectral imagery exploitation using evolutionary computing methods. Proc. SPIE Vol. 3118, p. 250-261, Imaging Spectrometry III, Michael R. Descour; Sylvia S. Shen; Eds.
2. Jones, Peter A.; Jungquist, Robert K.; King, Carl S. Spaceborne tactical sensor concept. Proc. SPIE Vol. 3061, p. 37-46, Infrared Technology and Applications XXIII, Bjorn F. Andersen; Marija Strojnik Scholl; Eds.
3. Kalman, Linda S.; Bassett, Edward M. Classification and material identification in an urban environment using HYDICE hyperspectral data. Proc. SPIE Vol. 3118, p. 57-68, Imaging Spectrometry III, Michael R. Descour; Sylvia S. Shen; Eds.
4. Krawczyk, H.; Neumann, Andreas; Walzel, Thomas; Hetscher, Matthias; Siegel, Herbert. Application of a multispectral interpretation algorithm to remote sensing data over the Baltic Sea. Proc. SPIE Vol. 2963, p. 234-239, Ocean Optics XIII, Steven G. Ackleson; Ed.

KEYWORDS: Fusion, Sensors, Monitoring, Surveillance, Reconnaisance, Remote Sensing, Earth Resources, Imagery Analysis, Image Enhancement, Visual Perception, Imagery Exploitation, Hyperspectral Imaging, Ultraspectral Imaging, Multispectral Imaging, Human System Interface

AF99-088 TITLE: Path Intercept Trajectory Algorithm

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Develop a real-time, adjustable intercept path algorithm to guide pilots back to a predefined path.

DESCRIPTION: Work continues at the Air Force Research Laboratory, Human Effectiveness Directorate on format and display of a head-up pathway in the sky (a.k.a., "Pathway") for use as a primary flightREFERENCE (Reising, Liggett, Solz, and Hartsock, 1995). The Pathway depicts a preplanned route to some desired endpoint (e.g., touchdown or weapon delivery). The problem consists of directing a pilot back to this predefined path once he or she is somehow diverted. The solution includes an algorithm (and associated display) capable of guiding the pilot back to the Pathway when it leaves the pilot's field of view. While the symbology associated with such an intercept path is now available, the underlying algorithm itself is not. Such an algorithm must run in real-time (i.e., be available to the pilot at the push of a button), lead the pilot back to the predefined path as quickly as possible, and be adjustable to accommodate variable specification of a variety of intercept path parameters. These parameters include minimum terrain and obstacle clearance, maximum bank angle, maximum Gs pulled, maximum pitch angles, and airspeed. The solution must be general enough to allow accommodation of a variety of aeromodels (e.g., fighter and transport aircraft) and must be as flexible as possible in accommodating starting speed, altitude, heading, attitude, and other flight parameters of the aircraft when the intercept path is generated.

PHASE I: Generate a design for the desired intercept trajectory algorithm. Define the algorithm's specifications and requirements, to include the hardware/software architecture necessary to have it respond to the pilot in real time.

PHASE II:Based on the products of Phase I, program and implement the desired algorithm. Phase II should result in a turn-key, open-system product suitable for immediate use in flight simulation and research.

PHASE III DUAL USE APPLICATIONS: The value of pathway-in-the-sky displays is now widely accepted by the aviation community. One indication of this is NASA's intent to spend over $10 million in the next several years to fund research and commercial development of these displays as part of its Aviation Safety program. In addition to certification, one of the few issues remaining as an obstacle to inclusion of these displays in civil aviation cockpits is the question of what to display when a pilot leaves the commanded path. An intercept algorithm of the type described above would have direct application in the solution of this problem and, as such, would be commercially transferable to any of the companies now investigating and designing pathway-in-the-sky displays for use in civil and general aviation cockpits.

REFERENCES:
Reising, J. M., Liggett, K. K., Solz, T. J., and Hartsock, D. C. (1995). Comparison of twohead up display formats used to fly curved instrument approaches. In Proceedings of the 39th Annual Meeting of the Human Factors and Ergonomics Society (pp. 1-5). Santa Monica, CA: Human Factors and Ergonomics Society.

KEYWORDS: HUD, Pathway, Intercept Algorithm, Primary Flight Imary, Primary Flight Display, Flight DOD Critical Technology

AF99-089 TITLE: Human Representation in System Requirements Definition Process

TECHNOLOGY AREA: Battlespace Environments

OBJECTIVE: Authoritative human behavior representation explicitly linking human performance and system effectiveness in constructive system analyses.

DESCRIPTION: In general, the representation of humans in constructive simulations is extremely limited. Decisions made early in the weapons systems acquisition process are typically without benefit of adequate consideration of the human. There is a need for representing the human interaction with complex automated systems in a way that will provide meaningful information to decision-makers involved in this process. The project will produce a technology for representing the behavior of individuals and teams, and for yielding explicit, operationally-credible, human-performance measures that can be directly linked to system effectiveness measures in engagement and mission-level constructive analyses. The scope is a technique for defining the limits of human performance that must be supported by the system interface (e.g., "the human interface must allow the operator to identify the target in less than two seconds, at a range of...") in order to satisfy overall system effectiveness objectives given the environment and other system performance parameters (and vice versa); it is not intended for defining the interface itself. The product will provide a capability for describing tasks and activities, information requirements, and human adaptability and variability in decision making to the extent necessary to support this end. Similarly, the product will account for constraints imposed by workload, such as the trade-off between time-to-perform and accuracy of performance. The technology advanced by this work will support the development of tools that represent human behavior in constructive models employed in the Analysis of Alternatives process, as well as in trade studies required to develop mission needs statements and operational requirements documents. As such, it must be demonstrably compatible with the DoD High Level Architecture (HLA). Users of this product are members of the acquisition and requirements communities who must make acquisition decisions based upon the anticipated performance of humans and weapons systems operating together. Human behavior representation, as referred to herein, means a computer-based model that mimics -- but does not necessarily replicate -- the behavior of either a single human or the collective action of a team of humans.

PHASE I: A descriptive framework will be completed. A final report will document issues, the framework, reviews, progress, and associated findings.

PHASE II:A breadboard will be developed and evaluated for a given military-based application. This breadboard will provide a demonstration of: (1) a capability to integrate representations of human performance into engagement and mission-level constructive simulations, (2) a capability to appropriately represent shifts in human-system goal states in response to changing demands in a mission environment, (3) human performance measures that trace the shifting goal structure and the human's ability to recognize a goal change, and then adapt performance accordingly, and (4) a performance assessment structure that links measures of human performance to system measures of effectiveness. A final report will document issues, needs and requirements, tradeoffs, problems, and findings.

PHASE III DUAL USE APPLICATIONS: This product is applicable to the conceptual design of any complex system that includes human components, so long as constructive representations of the system and environment exist or can be developed. Examples include: nuclear power plants, air traffic control, air and space craft, space mission control, metropolitan emergency management, and police command and control units.

REFERENCES:
1. Department of Defense (1995), Modeling and simulation (M&S) master plan, National Technical Information Service, Springfield VA 22161. http://www.dmso.mil/docslib/mspolicy/msmp/
2. Flach, J.M. & Dominguez, C.O. (1995), Use-centered design: Integrating the user, instrument, and goal, Ergonomics in Design, Human Factors Society, Santa Monica CA 90406-1369. July, 19-24.
3. Pew, R.W. & Mavor, A.S. (Eds.) (1997), Representing human behavior in military simulations (Interim Report), National Research Council, National Academy Press, Washington D.C..
4. Defense Modeling & Simulation Office (DMSO), DoD High Level Architecture (HLA), http://hla.dmso.mil/
5. Defense Modeling & Simulation Office (DMSO), Human behavior representation, http://www.dmso.mil/projects/hbr/

KEYWORDS: Modeling, Simulation, Performance, Effectiveness, System Design, Human Interaction, Constructive Model, Use-Centered Design, Human Centered Design, Human-System Interface, Human Performance Model, High-Level Architecture, Analysis of Alternatives, Human Behavior Representation

AF99-090 TITLE: Advanced Multifunction Head-Up Display (AMHUD)

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Develop advanced head-up display (HUD). Potentially integrate multifunction capability.

DESCRIPTION: There is a need to overcome technology barriers that prevent smaller, lighter, cheaper, more reliable HUDs of classical monochrome design from being manufactured. Also, it may be possible to combine a HUD light engine within a color head-down display (direct view or projection). Reliability improvements will significantly reduce expensive HUD maintenance actions. Present day HUDs use cathode-ray-tubes (CRTs) to produce the image. These CRTs consume high power at high voltage, have poor reliability, are subject to the vanishing vendor syndrome (VVS), and give an image with a line split, requiring an expensive dichroic optic system. Emerging display technologies may significantly improve the imaging source and eliminate some or all of the problems associated with the CRTs. Also, the optics might be designed with diffractive optics to significantly reduce the volume of present day HUDs, which presently jut into crew spaces making cockpit design, including ejection systems, extremely complex. An advanced HUD of classical functionality (compared to a present day HUD) would require 25 percent as much volume (0.5 vs. 2 cubic feet now), use 50 percent as much power, operate on lower voltage (28 V vs. about 10,000 V for CRTs), have half the weight (30 vs. 68 lbs. now), have an initial purchase cost of half as much ($85K vs. $170K), with 10X greater MTBF (2000 hr vs. 200 hr now).

PHASE I: Phase I is expected to result in a manufacturable design which takes into account reliability and maintainability issues for environments typical aircraft installations.

PHASE II:Phase II is expected to result in a prototype AMHUD to be delivered to the Air Force Research Laboratory for evaluation. The contractor may use feedback from these evaluations to refine a production design.

PHASE III DUAL USE APPLICATIONS: Displays are the quintessential dual-use technology. Military applications of AMHUD include the Air Force and other DoD aircraft. For example, the F-16 plans to initiate a program to replace the HUD with a new design in about 2003. Commercial applications include commercial airliners. Many airlines are fitting their aircraft with HUDs to give them access to airfields in bad visibility, thereby gaining a competitive edge. Civil aircraft fitted with HUDs are being certified to CAT III allowing them to land in almost zero visibility. The successful completion of this project could make HUDs viable for all types of military and civil aircraft. Similarly, the automotive industry is interested in installing advanced HUDs in production automobiles. Head-Up Displays are not now fitted in many aircraft (nor in most automobiles) primarily because of their high cost, size, and weight.

REFERENCES:
1. R. Venner, R.D. Lee, F.M. Meyer, and D.G. Hopper, "Advanced Head-Up Display Technology," in Cockpit Displays III, Proc SPIE 2734 (1996).
2. D.D. Desjardins and D.G. Hopper, "Military market for flat panel displays," in Cockpit Displays IV: Flat Panel Displays in Defense Applications , Darrel G. Hopper, Editor, Proc. SPIE 3057, Paper 50 (1997).
3. D.D. Desjardins and D.G. Hopper, "Military Display Market: First Comprehensive Edition", AFRL-HE-WP-TR-0017 [March 1998]. 298 pp.

KEYWORDS: Power, Electro-optics, Electron Devices, Information Fusion, Information Display, Crew Station Integration, Integrated Platform Electronics

AF99-091 TITLE: Advanced Virtual Human Sensory Interfaces

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Enhance operational Air Force through integration of human sensory feedback with virtual reality.

DESCRIPTION: A requirement exists for effective human performance and telepresent system controls that are based on natural, intuitive interfaces using innovative abilities and requiring no learning or training for efficient operation. The intuitive interfaces facilitate operator task performance, lessen mental and physical workload, reduce fatigue, and improve personnel safety. These intuitive interface technologies include, but are not limited to: 1) natural stimulation for perception of remotely-sensed tactile information, 2) high-fidelity force-reflecting haptic interface devices, 3) perceptually-driven control methods for teleoperated systems, 4) integrated hardware/software to superimpose position-calibrated virtual reality models with real-time video imagery, and 5) efficient computational algorithms for synthesizing interaction forces between virtual objects in a virtual environment. Innovation is needed in order for these technologies to be effective in remote and/or high-stress environments characteristic of military operations. This topic represents an opportunity for innovative ideas to be applied to individual components, the integration of multiple components, and the application of these to address current Air Force and DOD deficiencies in man-machine interfaces. These issues will be even more important in the future within the reduced force structure environment. A single interface issue or any combination of interface issues may be addressed in the offeror's proposal.

PHASE I: Phase I efforts would provide an assessment of the state of the art and an approach to develop an appropriate intuitive interface technology.

PHASE II: Phase II efforts would provide a demonstration and validation of the intuitive interface technology.

PHASE III DUAL USE APPLICATIONS: Commercial applications of these technologies are possible in the commercial aviation, entertainment, industrial safety, and health care fields, as well as in telemedicine, environmental cleanup, and nuclear facility operation.

REFERENCES:
1. M.W. Haas, and L.J. Hettinger. "Applying Virtual Reality Technology to Cockpits of Future Fighter Aircraft," Virtual Reality Systems: Applications, Research and Development, I(2), pp. 18-26, 1993.
2. D.A. Kontarinis and R.D. Howe, "Tactile Display of Vibratory Information in Teleoperation and Virtual Environments", Presence: Teleoperators and Virtual Environments, 1995.
3. G. Burdea and P. Coiffet, "Virtual Reality Technology", John Wiley & Sons, New York, 1994.

4. C.J. Hasser, "Multi-Element Tactile Feedback for Teleoperations", VR Systems '93, SIG-Advanced Applications, New York, NY, October 1993.
5. L.B. Rosenberg. "The Use of Virtual Fixtures as Perceptual Overlays to Enhance Operator Performance in Remote Environments," USAF Technical Report AL/CF-TR-1994-0089, December 1994 (DTIC AD: A292450). Unclassified. Distribution Unlimited.

KEYWORDS: Telesurgery, Telerobotics, Telepresence, Exoskeletons, Remote Surgery, Virtual Reality, Telemanipulation, Tactile Feedback, Force/Torque Feedback, Synthetic Environments, Operator-Robot Interface, Human-Machine Interaction

AF99-092 TITLE: Compact Ultrashort Laser Sources

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop a commercially viable ultrashort laser pulse source.

DESCRIPTION: Ultrashort laser pulses have enormous potential in commercial, industrial, medical and aviation applications. However, present ultrashort laser sources are essentially laboratory developmental units requiring a relatively large space and a well-controlled environments. Research is needed to build an ultrashort laser system that is very compact and requires minimal maintenance for continued short-pulse production. An initial assessment will determine the possibility to build such a laser system in a 2-foot by 2-foot by 3-foot housing, with all material internal, with the possible exception of the power supply.

PHASE I: Phase I will result in the determination of feasibility, technical design and proof-of-concept for the compact ultrashort laser source.

PHASE II:Phase II will develop a prototype turn-key laser system which will produce very large energy laser pulses (e.g. greater than 5 mJ per pulse) shorter than 500 femtoseconds in duration.

PHASE III DUAL USE APPLICATIONS: Research is presently discovering the ability of ultrashort laser sources to effectively machine to dimensions smaller than the optical diffraction limit. In addition, commercial applications such as paint removal, thin coat deposition and medical diagnosis and treatment are well within technical achievement and will be facilitated by the availability of compact laser sources.

REFERENCES: M.D. Shirk and P.A. Molian, A review of ultrashort pulsed laser ablation of materials, Jour. Laser Applications Vol. 10, No. 1, 18-28 (1998).

KEYWORDS: Compact Lasers, Ultrashort Lasers, Femtosecond Lasers

AF99-093 TITLE: Advanced Battery For Head and Helmet Mounted Night Vision Devices

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Develop an environmentally benign battery to power night vision devices in extreme cold.

DESCRIPTION: Night vision device batteries are required to provide the proper current and voltage to power one, two, or even four image intensifier tubes for long periods of time at extreme temperatures. The batteries currently available that can meet this requirement are large, heavy, not readily available, expensive, and/or present an environmental hazard when discarded. To improve the quality of the night vision device human system interface, this effort will focus on the design, fabrication, assembly, and testing of a single, compact battery which can reliably power an aviator's night vision device, the AN/AVS-8, at low temperatures for at least six hours and pose no environmental hazard upon disposal. The dimensions and weight of batteries resulting from this research will be no greater than the dimensions and weight of the common AA alkaline battery (goal of less than or equal to the 1/2 AA battery). Battery designs will be required to provide at least 55mA at 2.0V or greater for at least six hours at -34 degrees Celsius. A tester integral to the battery should also be included in the design.

PHASE I: Research will result in a design that takes into account the power, size, weight, environmental, and reliability requirements mentioned above and is ready for fabrication and assembly. The design will include any support equipment required to maintain the battery in the field and address issues surrounding interfacing the battery with current night vision devices. Delivery of a laboratory demonstrator prototype at the end of Phase I is highly desirable.

PHASE II:The design from Phase I will result in several prototype batteries, support equipment, and any required apparatus for interfacing the battery with existing night vision devices. The contractor is expected to participate in testing and to receive feedback from the Air Force for a possible future production version of the design.

PHASE III DUAL USE APPLICATIONS: Long life, environmentally benign batteries would have great commercial potential. They would generate large cost savings in both civilian and military markets by reducing the frequency of battery replacement and eliminating the need for special disposal procedures. Advances in low temperature battery life would yield even greater improvements in battery performance at room temperature, significantly increasing battery life over current commercially available products. Replacing high power density and rechargeable batteries (lithium and NiCd batteries, for example) with the device resulting from this research would also eliminate the environmental hazards posed by improper disposal.

REFERENCES:

1. Barak, M. (1980). Electrochemical Power Sources; Primary and Secondary Batteries, Peter Peregrinus, Ltd., Stevenage, UK. Csorba, I.P. (1985). Image Tubes. Howard W. Sams & Co., Inc., Indianapolis, IN.
2. Kiehne, H.K. (1989). Battery Technology Handbook, Marcel Dekker, Inc., New York.
3. Linden, D. (1995). Handbook of Batteries, 2nd edition, McGraw-Hill, Inc., New York.

KEYWORDS: Current, Voltage, Battery, Head Mounted, Cold Weather, Light Weight, Night Vision, Battery Life, Helmet Mounted, Night Vision Goggle, Night Vision Device, Image Intensifier Tube

AF99-094 TITLE: Development of Life Support Ensemble Utilizing Smart Materials

TECHNOLOGY AREA: Biomedical

OBJECTIVE: Develop fully integrated life support ensemble, including partial pressure suit and mask tensioning devices, from newly developed smart materials.

DESCRIPTION: Current aircrew life support ensembles utilize air bladders to provide counter-pressure for mask tensioning, +Gz protection, and altitude protection. These bladders can be cumbersome, bulky, and uncomfortable to the pilot during tactical maneuvers. Air bladders also present a filtering/contamination problem in the chemical/biological defense environment. A suit composed of contractile fibers or sheets of "smart materials" would decrease the equipment weight and bulk. Smart materials can be used as sensors, actuators, and as control mechanisms. These materials have superior strength-to-weight ratios and have the potential to provide greater protection to the pilot than current life support systems. Hydrogels, which swell and contract in response to the degree of ionization, could be used in ear-cup and mask seals. Nitinol, a type of shape memory alloy, contracts when an electrical current is applied. This material could be woven into a fabric and used as either a counterpressure garment or as a mask tensioning device. Other smart materials, such as silver-coated nylon, might also be utilized in a life support equipment ensemble. Benefits which might be realized by using smart materials include less weight, greater compatibility with chemical and biological defense ensembles, less mobility restrictions, and reduced heat stress. A fully integrated "smart" life support ensemble, which provides superior mask tensioning, helmet stability, and mechanical counter-pressure would greatly improve pilot performance and protection.

PHASE I: Phase I will result in (1) identification of necessary mechanical and material properties needed to construct a life support ensemble out of smart materials, (2) an assessment of current smart material technology and how well they meet the criteria established in Part 1, (3) recommendations on critical areas of materials research that should be pursued, and (4) preliminary conceptual drawings of proposed life support equipment.

PHASE II:Phase II will result in life support ensemble prototypes that could be used in human test evaluations.

PHASE III DUAL USE APPLICATIONS: Primary market for this technology is in military aviation. Some of the technology developed in this effort could also be applied to commercial respirators, the deep sea diving community, and to counterpressure garments to counteract low blood pressure. Smart systems also have potential use in a variety of sports equipment, including bicycle and football helmets, exercise clothing, and compressive bandages after injury.

REFERENCES:

1. Ouellette, J. (1996). How smart are smart materials? The Industrial Physicist. (Vol 2, pp 4).
2. Rogers, CA (1995) Intelligent materials. Scientific American. 154-157. (Sep 1995)
3. Hoffman, AS (1991) Environmentally sensitive polymers and hydrogels. MRS Bulletin. 42-46. (Sep 1995)

KEYWORDS: Oxygen Mask, G-Protection, Counterpressure, Smart Materials, Partial Pressure Suit

AF99-095 TITLE: Altitude Decompression Sickness Risk Assessment Computer (ADRAC)

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop software/hardware for the Altitude Decompression Sickness (DCS) Risk Assessment Computer (ADRAC) based on validated models developed at AFRL/HEPR.

DESCRIPTION: The Air Force has an interest in determining the risk of altitude decompression sickness and seeks development of a software package, a hand-held ADRAC, and a panel-mounted indicator. The software will use the existing, computerized, AFRL model of DCS risk which is statistically based on AFRL research data and mathematically based on a system of partial differential equations describing bubble growth. High altitude exposure in aircraft, hypobaric chambers and with extravehicular activity (EVA) in space results in an inherent risk of decompression sickness (DCS). In the past, general guidelines for safer altitude exposures have been developed through costly, time-consuming studies, each specific to unique scenarios of altitude exposure. Rapidly changing technology in aircraft design and mission requirements e.g., high altitude air drops, demand improved capabilities in predetermining and immediately determining an individual's decompression risk assessment. Unlike the diving community, a standardized method for altitude decompression sickness risk determination does not presently exist. In 1990, a new bubble growth algorithm and a statistical model based on the existing DCS Database were initiated at Brooks AFB. The first version of this combined model was completed in 1996 and several papers have been submitted for publication. The model is being validated and is expected to be available in January, 1999. Information on the data required for a proposal may be obtained by calling the author. At that time, an updated version of the model, based on the validation, will be produced and software development can be initiated. Utilization of such software and hardware is anticipated in cockpits, in hyperbaric chamber control stations, in EVA suits, in commercial and private general aviation aircraft, as well as mission planning computers for high altitude operations. Applications of this technology would specifically aid aviators, special operations personnel, and civilian aviators/passengers in determining altitude decompression sickness risk.

PHASE I: Develop a software package/disc based on the AFRL model of altitude decompression sickness risk assessment. The risk assessment output will be a percentage of risk or prebreathe time to reduce the risk to zero.

PHASE II:Develop a hand-held Altitude Decompression Sickness Risk Assessment Computer (ADRAC) and a panel-mounted ADRAC for aircraft using the resulting software package developed in Phase I. The panel-mounted ADRAC will use inputs from the pilot and cabin pressure as provided by an aircraft system. The panel-mounted ADRAC will provide percentage of risk as a product and would alert the pilot via the Master Caution system.

PHASE III DUAL USE APPLICATIONS: Some civilian aircraft have the capability of reaching altitudes up to 30,000 feet mean sea level (MSL) unpressurized and even up to 50,000 feet MSL with pressurized cabins. Balloonists and parachutists also reach into these potentially hazardous flight levels. An ADRAC computer/panel simple indicator light (LCD) could warn these aviators of different decompression sickness risk assessment levels; e.g., green (safe), yellow (increased risk), and red (dangerous risk) via the Master Caution system. Currently available hypoxia (lack of oxygen) models could be integrated into these units so that civilian aviators could determine their risk of altitude hypoxia.

REFERENCES:

1. Petropoulos, L.J., Petropoulos, P.G., Pilmanis, A.A., Mathematical analysis of bubble growth models applied to altitude decompression sickness. J. Math. Biosci.
2. Petropoulos, L.J., Pilmanis, A.A., (1977). A mass diffusion-induced bubble growth model for altitude exposure. Aviation Space Environment Medicine. 68:625.
3. Kannan, N. Petropoulos, L.J., Raychaudhuri, A. Pilmanis, A.A. (1977). An altitude decompression sickness risk assessment model. Aviation Space Environment Medicine. 68:625.
4. Kannan, N. Raychaudhuri, A., (1997) Survival models for predicting altitude decompression sickness. AL/CF-TR-1997-0030, 1997. Unclassified/Distribution Unlimited.
5. Kannan, N., Raychaudhuri, D.A., Pilmanis, A.A., Logistic models for altitude decompression sickness. Aviation Space Environment.

KEYWORDS: Hypoxia, Decompression, Denitrogenation, Risk Assessment, Decompression Sickness, Decompression Computer, High Altitude Protection, ADRAC (Altitude Decompression Sickness Risk Assessment Computer)

AF99-096 TITLE: Distributed Team Knowledge Representation and Scenario-Based Performance Evaluation Methods

TECHNOLOGY AREA: Manpower, Personnel, and Training

OBJECTIVE: Develop collaborative methods for identifying,eliciting and representing knowledge and core competencies for training and performance support and for deriving and scoring task-based scenarios for assessing team performance and readiness.

DESCRIPTION: Recent advances in distributed methods for training, simulation, and performance support demonstrate that it may be feasible to develop an online (near real-time) capability to decompose elements of work activity into knowledge- and competency-based components. Such a capability will permit near-real-time knowledge elicitation and specification for developing models of expertise and for identifying key aspects of performance required to meet mission requirements. Research on team performance assessment has underscored the importance and difficulty of specifying the criterion performance space and the gathering of detailed objective situations related to the performance of teams. Also recent efforts to develop high fidelity performance assessment methods for aircrew members have demonstrated the importance of situationally-based criterion measures for performance and readiness enhancement. However, generating and scoring scenarios for use in assessment has been prohibitively expensive. This effort will develop distributed methods for identifying and eliciting the knowledge and competency-based representations of work activities. Current methods for obtaining knowledge representations are inefficient and time-consuming to implement. Therefore this effort will develop distributed methods for determining knowledge and competency requirements for individual and team work tasks. This effort will also develop and validate methods to generate work sample scenarios to systematically assess the performance and readiness teams. The criterion performance measures are situationally-based assessments from which actual test scores would be obtained. A distributed method for generating scenarios, to be used as task-based work-sample performance instances, will be developed and tested. These high fidelity assessments not only provide critical information about how all members would perform in the given situation, but the data on their responses can be used to identify innovative solutions, misconceptions about the appropriate solution, and incorrect information that could be addressed in follow-on education and training programs.

PHASE I: Phase I will result in a proof-of-concept technology for representing knowledge and competencies to drive training and performance support development. It will also provide a baseline methodology to generate scenarios and prototype scoring algorithms for performance assessments in distributed environments. Exemplar scenario-based criterion measures and data generation methods will be demonstrated in two domains. The domains will be related to military team performance such as mission planning and performance and to non-military domains such as regional sales teams or product development teams.

PHASE II:Phase II will fully develop, apply, test, refine, and validate the knowledge elicitation and representation methodology and will develop a distributed scenario generation and scoring technology to assess workgroup and team performance and readiness. Proposals should assume that the technology will run in a platform-independent environment.

PHASE III DUAL USE APPLICATIONS: This effort will produce a cost-effective capability to elicit and identify core knowledge and competencies required by teams and will develop a near-real-time capability to generate and score scenarios for use in performance and readiness assessments teams. The results applicable to industry as competency-based selection, placement, and training approaches become commonplace with increased job enlargement and workforce globalization. The developed capability will provide the means to efficiently and reliably gather important knowledge information for specifying job, training and performance support requirements. In addition, scenario-based performance assessments offer companies with tools to accurately identify areas of high performance, areas of potential problems, and additional education, training, or management requirements. The benefits from such a capability to Government and Private Sector agencies could help organizations save considerable time and expenditures by targeting selection, training, and measurement to address specific, situationally-relevant areas of performance and productivity.

REFERENCES:
1. Fowlkes, J.E., Lane, N.E., Salas, E., Franz, T., & Oser, R. (1994). Improving the measurement of team performance: The TARGETS methodology. Military Psychology, 6, 47-63.
2. Guzzo, R.A., & Salas, E. (1995). Team effectiveness and decisionmaking in organizations. San Francisco: Jossey Bass.
3. Hall, E.P., Gott, S.P., & Pokorny, R.A. (1995). A procedural guide to cognitive task analysis: The PARI methodology. (Report No. AL/HR-TR-1995-0108). Air Force Materiel Command, Brooks Air Force Base, TX. (AD A303 654)
4. Kraiger, K., Ford, J.K., & Salas, E. (1993). Application of cognitive, skill-based, and affective theories of learning outcomes to new methods of training evaluation. Journal of Applied Psychology, 78, 311-328.
5. Lance, C.E., Douthitt, S., Johnson, C.D., Bennett, W. Jr. (1998). Good news: Work samples are (about) as valid as we've suspected. Paper presented at the annual conference of the Society for Industrial and Organizational Psychology (SIOP), Dallas, TX.

KEYWORDS: Program Evaluation, Team Effectiveness, Readiness Evaluation, Criterion Development, Performance Enhancement, Performance Measurement, Workgroup Effectiveness, Competency-based Assessment, Knowledge Elicitation and Representation

AF99-097 TITLE: Training Management Decision System for Team Training Evaluation and Tracking

TECHNOLOGY AREA: Manpower, Personnel, and Training

OBJECTIVE: Design, develop, and demonstrate a training management system for scheduling and tracking of C3I team training and provide systematic evaluation capabilities using intelligent agents and expert systems technology.

DESCRIPTION: Training budgets in all military services are undergoing massive cuts at a time when training is more essential than ever before in our history. Initial and sustainment training of active duty, guard, and reserve warfighters poses major problems and challenges to the military services. Training warfighter personnel in academic schools (ground-based training), simulator training, flight training, and on-the-job training requires scheduling, tracking and systematic evaluation of individual and team performance. Field commanders and supervisors must know who has the requisite training in order to identify the most appropriate individuals or teams to be deployed to the field. Scheduling and tracking students is a major issue especially for guard and reserve units that also must meet the same training requirements as active duty. All training programs, whether lecture or automated, require training management to support individual training and team training evaluation. Most training management systems support maintenance training from an individual perspective. With an eye on the downsizing of the military, team training of aircrews, space operations, and even team training of maintenance personnel is a driving force and primary focus of all military services. An automated means of identifying required sustainment and core-task training requirements and for managing and tracking formal and field (on-the-job) training completion and certification is a critical necessity. The Air Force's present capabilities in scheduling, tracking and evaluation for this type of training are completely inadequate. A training management system must be capable of making decisions in scheduling and tracking performance of individuals as well as teams. Currently, training management systems cannot make decisions and are not conducive to changes with having a system failure forcing instructors to schedule by hand. Some of the primary factors relevant to training management are administration, resources, curriculum, courseware, scheduling, evaluation, remediation, training reports generation, configuration, and logistics. Students have requirements that interfere with training and a training management system must comply and be able to make decisions for rescheduling. The system must be able to run on a desktop Pentium Level PC and be easily used by instructor/training personnel. Intelligent agent and intelligent programming architectures are at a point of technological maturity today to facilitate their application for this effort. Intelligent decision making for scheduling and tracking has not been accomplished at the team training level but now presents itself as a great opportunity for research in this area.

PHASE I: The end product for Phase I shall be a fully functional, computer-based prototype demonstrating scheduling, tracking, and performance assessment of individual students and students in a team training environment. A technical report of the prototype performance is also required.

PHASE II:The end product of Phase II shall be a fully functional training management system demonstrated in an operational field setting and a technical report documenting all aspects of the system and lessons learned.

PHASE III DUAL USE APPLICATIONS: This type of system has the capability for use in public school systems, industry training, and for all other government and military training requirements. Any of the other services could use this system as it would be a viable training system for C3 regardless of the mission differences.

REFERENCES:
http://www.ott.navy.mil/2_3index.htm
http://www.aims.r.army.mil/

KEYWORDS: Training, Logistics, Scheduling, Intelligence, Collaboration, Administration, Decision-Making, Team Performance, Training Management, Performance Measurement

AF99-098 TITLE: Development of Predictive Model for Rocket Launch Noise Footprint

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Develop a software model of rocket noise useful for evaluating impact on wildlife and communities.

DESCRIPTION: The initiation of spacelift or other rocket vehicle launch programs by the government requires an assessment of the environmental impacts created by the resultant noise under the National Environmental Policy Act (NEPA). This may involve either new or modified vehicles, or new locations/launch conditions. In the past, the noise levels have been estimated by similarity to other vehicles, or by simplified manual calculations involving the rocket engine characteristics. These fail to give a complete two-dimensional noise profile and do not account for the effects of topography or meteorology. The objective of this project is to develop a software model of rocket noise useful to evaluating impact on wildlife and communities. Numerous field measurements of actual launches are available for model validation or for empirical modeling. The model must have the capability of developing quality graphics to depict dBA sound levels or sound levels in different frequency bands, overlaid on local maps.

PHASE I: Initial Phase I activity shall include a complete review of current acoustic generation/propagation technology as applied to rocket engines, and development of a software architecture for modeling. The user interface shall be defined and a demonstration prepared for a limited sample set of conditions.

PHASE II: Phase II activity shall complete the model development in a manner to permit use on any current or defined future rocket system by U.S. or foreign vehicles. Input and output procedures shall be refined for user-friendliness and publishable graphic outputs. A demonstration shall be performed, whereby an upcoming launch will be analyzed, the acoustic footprint predicted, and actual field measurements taken for validation.

PHASE III DUAL USE APPLICATIONS: The effects of launch vehicles acoustics on community acceptance and wildlife is a major concern of the military, commercial ventures and NASA. To broaden the base for commercialization, this model program should be expanded to allow inputs and suitable outputs for turbo jet-propelled aircraft (military and commercial) as well. This would allow for general use in environmental analyses by NASA, FAAA, civil and other land use planning authorities.

REFERENCES:

1. Gruner, W. J., (Teledyne Brown Engineering Co., Huntsville, AL), A Unitary method for prediction of rocket engine noise (Acoustic Environmental prediction model for near, mid and far field rocket engine noise). In: Noise and vibration control engineering; Proceedings of the Purdue Noise Control Conference, Lafayette, IN, July 14-16, 1971. (A72-29553 13-23)Lafayette, IN, Purdue University, 1972, p. 503-509.
2. McInerny, S. A., Characteristics and predictions of far-field rocket noise, Noise Control Engineering Journal, Vol. 38, N. 1, Jan-Feb 1992, p. 5-16, 1992.
3. Plotkin, K.J., Prediction of rocket noise footprints during boost phase, AIAA/CEAS Aeroacoustics Conference, 3rd, Atlanta, GA May 12-14, 1997, 8p. 1997. (AIAA paper 97-1660).

KEYWORDS: Noise, Acoustic, Space Launch, Community Impact, Endangered Species, Two-Dimensional Noise Profile

AF99-099 TITLE: Logistics Technology for Weapon System Support

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Develop technology to improve Air Force sustainment logistics in areas of supportability, deployability, and affordability.

DESCRIPTION: The Air Force requires a flexible, agile, fast-response, and affordable logistics infrastructure to achieve the goals of Agile Combat Support, Lean Logistics, and the Rapid Air Expeditionary Force (explained in theREFERENCEs). Research is needed to develop new techniques and tools for order of magnitude improvements to the acquisition, planning, maintenance, supply, transportation, and deployment of wholesale logistics functional areas, in support of both land and space-based assets. Focus can be on any of the aforementioned functional areas, either singly or in combination. Highly innovative, futuristic concepts will be given much higher consideration than mere incremental improvements to existing capabilities. Emphasis should be placed on technology that improves maintainability, streamlines logistics processes, reduces deployment footprint, and reduces logistics support costs. Examples include automated generation of technical data; advanced materiel/cargo handling equipment; miniaturized, multi-function bare-base facilities equipment; and maintenance/supply of space-based systems. Products may be either hardware or software prototypes, but must be designed so that they can be easily integrated into the Air Force's wholesale logistics environment.

PHASE I: Phase I will result in a final report which documents a requirements analysis, proposed design, projected payoff, commercialization strategy, and a plan for Phase II.

PHASE II:Phase II will result in a prototype technique/tool, a field test to demonstrate the feasibility and payoff, a cost/benefit analysis and associated documentation. The product is a software/hardware tool that improves a specific dimension of logistics support.

PHASE III DUAL USE APPLICATIONS: Commercial development of complex systems should involve the concurrent development of the system's support infrastructure. While deployability may not always be a design consideration in all commercial developments, affordability of the support tail certainly is. Thus the results of this effort would apply to the commercial sector.

REFERENCES:

1. DOD Joint Vision 2010, DTIC Accession Number AD-A311 168 www.dtic.mil/doctrine/jv2010/
2. DOD Logistics Strategic Plan, www.acq.osd.mil/log/mdm/lsp98.htm
3. AF Global Engagement, DTIC Accession Number AD-A318 235, www.xp.hq.af.mil/xpx/21/nuvis.htm

KEYWORDS: Supply, Planning, Logistics, Deployment, Maintenance, Sustainment, Acquisition, Transportation, Life Cycle Costs

AF99-100 TITLE: Impact Injury Modeling Software and Interfacing for the Biodynamic Work Environment

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Development and computer interfacing of biodynamic injury models and criteria for use in the prediction of acceleration impact injury.

DESCRIPTION: Researchers at the Air Force Research Laboratory have performed extensive studies of biodynamic response to impact acceleration. These studies encompass thousands of tests conducted with both human volunteers and instrumented manikins performed over a span of more than 30 years. Results of these studies have been used to enhance the safety of escape system and crash protection design and to provide data for models which are used to predict the potential of injury. Data from these tests include biodynamic accelerations, forces, and displacement time histories, along with subject anthropometry measurements. These data have been integrated into a large in-house data repository which has been named the Biodynamics Data Bank (BDB). The time history files of all tests in the BDB are stored in an MS Excel format, along with tables and queries in an MS Access data base. The BDB will become part of a comprehensive Biodynamics Work Environment (BWE), which has been envisioned to give researchers the capability to easily access all these data and integrate them with biodynamic models in order to quickly solve problems in the areas of human safety and performance.

This topic addresses the need for integrating the BDB with injury models and criteria which can be used to assess the probability of injury during impact acceleration stresses, with particular focus on neck and spinal injury. The injury models can be selected from current or modified models already in use or newly developed ones. They should address the effects of both the duration and magnitude of applied acceleration pulses and/or resulting loads and moments. Equations on which the models are based should be furnished along with information on why the model is appropriate, andREFERENCEs provided if a currently accepted model is employed (e.g. Head Injury Criterion (HIC), Dynamic Response Index (DRI), etc.). The software should be sufficiently flexible to allow the researcher to select the most appropriate injury criteria level for the model (e.g. Mertz, Yamada, etc.), and whenever possible provide the user with multiple probability of injury level curves (e.g., 1 percent, 5 percent , 50 percent, etc.). The software should be able to interface directly with the BDB by allowing the researcher to input acceleration, force, or moment time history or peak data files in MS Excel format. The software should be user-friendly, menu-driven, and written in a common language such as MS Visual Basic.

PHASE I: Should contain a brief description of the proposed models, injury indices, and injury criteria, and a demonstration program which illustrates the use and capabilities of the integration software. It should also contain two or more example models.

PHASE II:Should result in a complete graphical user interface with all of the selected models, injury indices, and injury criteria fully integrated into the software. It should also have features which enable the user to add new models or modify existing ones.

PHASE III DUAL USE APPLICATIONS: This technology will provide information which can be used by civil aviation and automotive safety researchers in the understanding and prediction of neck and spinal injuries incurred during crashes.

REFERENCES: Raddin, J.H., Scott W.R., and Bomar, J.B, et al. Adapting the Advanced Dynamic Anthropomorphic Manikin (ADAM) Technology for Injury Probability Assessment, AL-TR-1992-0062, (AD A252 332), Armstrong Laboratory Wright-Patterson AFB, OH.

KEYWORDS: Database, Neck Injury, Injury Index, Injury Model, Spinal Injury, Human Volunteers, Impact Acceleration, Instrumented Manikins

AF99-101 TITLE: Human Interface Solutions for Emergency Escape System

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Develop innovative technology to increase crewmember comfort/reduce fatigue during extended missions and to protect the crewmember during high-speed ejections.

DESCRIPTION: Ejection seat improvements are sought in three separate areas. These are the development of seat cushions with improved comfort, full crew population accommodation, and ejection compatibility; a full crew population accommodating restraint system with pelvic retraction and commanded haul back capability; and a passive head/neck restraint system for use with existing and future ejection seats. Extended missions in fighter aircraft have made lack of comfort associated with the present Advanced Concept Ejection Seat (ACES) II cushions no longer tolerable. Since these cushions were designed in the 1970's, the automotive industry has made great strides in improving seat comfort. However, the dynamic characteristics of automobile seats are inappropriate for ejection seats where the cushions must not contribute to increased injury during catapult acceleration. A safe, comfortable cushion design must accommodate the full Joint Primary Aircraft Training System (JPATS) pilot population as well. During some flight maneuvers it is possible for the pilot to be lifted out of the seat because the current PCU-15 restraint has little negative G restraint and marginal lateral restraint. Small females are typically even less well restrained. During flight maneuvers when pilots are out of position, they would benefit from an inertia reel, which has a commanded haul back feature to reestablish proper seat contact and flight control interface. Ideally the restraint system should give the pilot freedom to move during flight, e.g. to "check-six" etc., and should provide both upper torso and pelvic retraction to properly position the pilot for safe escape. Full accommodation is a must. Ejection at high speed exposes the crewmember to injurious aerodynamic forces on the head/neck. New helmet-mounted systems make matters worse. A passive head/neck protection system is needed to counteract these aerodynamic forces and allow helmet-mounted systems to provide their considerable performance advantages without compromising safety during ejection.

PHASE I: Develop initial designs and associated analysis to select the most promising approach. Preliminary demonstration of the chosen design is preferred but not required. Document the approach, initial designs and preliminary results (if available) in a final report.

PHASE II:Fabricate and test the final prototype system. Evaluate results and develop a plan for follow-on development. Prepare a final report describing the design along with the test results and recommendations for insertion of the design into applicable Air Force and commercial systems.

PHASE III DUAL USE APPLICATIONS: Since these problems need solution in order to protect and improve comfort, improve safety during ejection, and decrease fatigue during long flights, effective solutions will find a market in both retrofit to existing seats and for inclusion in future ejection seats world-wide. The concepts developed will also find application in the commercial air and automotive industries.

REFERENCES:

1. Van Ingen-Dunn, C. and Richards, M., Feasibility of Reducing Incidence of Low Back Pain in Helicopter Pilots Using Improved Crew Seat Cushions. AL-SR-1991-0009. (AD-A178 317). Wright-Patterson AFB OH.
2. Brinkley, J. W., et al. Evaluation of a Proposed F-4 Ejection Seat Cushion by +GZ Impact Tests, AL/CF-TR-1993-0160, July 1993. (AD A289 700). Wright-Patterson AFB OH.
3. Perry, C. E., Evaluation of a Proposed B-2 Seat Cushion by +Gz Impact. AL/CF-TR-1997-0112, February 1997. (AD A339 408) Wright-Patterson AFB OH.
4. Cass, S., Peck, W., Duncan, Jr., Castiel, H., Crew Escape Technologies (CREST) Mission Area Requirements Study Current and Future Crew Escape Requirements, AL-TR-1992-0183. (AD A269 069). Wright-Patterson AFB OH.

KEYWORDS: Seat Comfort, Inertia Reels, Injury Criteria, Restraint Systems, Commanded Haulback, Aircraft Seat Cushions, Aircrew Safety and Protection, Aerodynamics of Human Head/Neck

AF99-102 TITLE: Advanced Methods for Displaying Large Schematics on Small Screen Devices

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop an advanced method for presenting large schematics on small screen computer devices.

DESCRIPTION: In the future, aircraft maintainers will be performing all of their maintenance tasks with the aid of a portable computer. The portable computer will be used to present their job assignments, technical instructions, graphics for ordering parts, troubleshooting information and maintenance completion forms. For these computers to be tools that assist the maintainer, they must be light-weight, portable, and responsive. The small size of the computer facilitates use, but creates new problems in presenting technical information. One of the problems with a portable computer is the size of the display for presenting information. This problem is exaggerated with maintenance tasks due to the requirement for presenting large graphics, schematics, and complex wiring diagrams. The portable maintenance computer must provide the technician with the capability of viewing all of the electronic signal information required to diagnose a fault. In addition, the computer must minimize the requirement for scrolling and zooming on the flight line. The intent is to reduce technician workload, not increase it with demanding graphic presentation requirements. The goal of this effort is to develop an improved presentation concept and not enhanced software graphics applications.

PHASE I: The purpose of this phase will be to define new methods and techniques for presenting large schematics and complex graphics.

PHASE II:A technology demonstration of the methods and techniques established in Phase I will be the product of this phase. In addition, provide specific recommendations for the application of this technology for both DOD and commercial use.

PHASE III DUAL USE APPLICATIONS: The technology developed under this program will have a high commercialization potential, applicable to virtually any maintenance environment in the government and civilian sector.

REFERENCES:
1. Furnas, G. W. (1988). Generalized Fisheye Views. CHI' 86 Proceedings. ACM Press, 16-23.
2. Mitta, D. A. Advanced User Interface Capabilities for Application of Portable Computers AL-TP-1992-0002. Brooks AFB TX, (ADA247 295), Logistics Research Division, Human Resources Directorate.
3. Frey, P.R., Rouse, W.B., & Garris, R. D. (1992). Big graphics and little screens: Model-based design of large scale information displays (Technical Report No. STI-TR-8817-003). Orlando FL: Naval Training Systems Center.
4. Wampler, J. L. (1998). Task Filtered Display of Functional Diagrams for Flight Line Maintenance (Technical Report No. (To Be Determined)). Wright Patterson AFB OH: Crew Survivability and Logistics Division, Human Effectiveness Directorate

KEYWORDS: Simplified Schematics, Computerized Wiring Diagrams, Computer-based Electronic Schematics

AF99-103 TITLE: Advanced Audio Interfaces

TECHNOLOGY AREA: Human Systems Interface

OBJECTIVE: Enhance operational Air Force audio command, control, and communications systems.

DESCRIPTION: A requirement exists for effective audio command, control, and communications systems that are based on natural, intuitive interfaces using innovative abilities and requiring no learning or training for efficient operation. The intuitive interfaces facilitate operator task performance, lessen mental and physical workload, reduce fatigue, and improve personnel safety. These intuitive interface technologies include, but are not limited to: 1) auditory system modeling and neural networks for robust signal processing of speech, 2) digital audio technology to allow integration into aircraft systems, 3) noise-induced hearing loss protection, 4) active noise reduction, 5) three-dimensional auditory display for spatial awareness and communications, 6) high-performance noise canceling microphones. Innovation (e.g. auditory system modeling and neural networks) is needed in order for these technologies to be effective in high-noise (in some cases in excess of 140 dB) and high-stress environments characteristic of military operations. This topic represents an opportunity for innovative ideas to be applied to individual components, the integration of multiple components, and the application of these to address current Air Force and DOD deficiencies in audio command, control, and communications and man-machine interfaces. These issues will be even more important in the future within the reduced force structure environment.

PHASE I: Create an innovative interface concept, analyze operator performance and technology feasibility, and produce and deliver a proof-of-concept demonstration, including performance analysis.

PHASE II: Optimize the innovative interface system design, produce, evaluate, and deliver a full-scale prototype of the new interface concept, including full software documentation.

PHASE III DUAL USE APPLICATIONS: Commercial applications of these technologies are possible in the commercial aviation, entertainment, industrial safety, and health care fields, as well as in telemedicine and nuclear facility operation or in any high stress high workload environment.

REFERENCES:
1. DeSimio, M.P., and Anderson, T.R., (April 1993) Phoneme Recognition with Binaural Cochlear Models and the Stereausis Representation, IEEE Procedure International Conference on Acoustics, Speech, and Signal Processing, Vol. I, pp. 521-524, Minneapolis, MN.
2. Haas, M.W., and Hettinger, L.J. (1993) Applying Virtual Reality Technology to Cockpits of Future Fighter Aircraft, Virtual Reality Systems: Applications, Research and Development, I(2), pp. 18-26.
3. McKinley, R.L., Ericson, M.A., and D'Angelo, W.R. (May 1994) 3-D Auditory Displays - Development, Applications and Performance. Aviation, Space and Environmental Medicine.
4. Nixon, C.W., McKinley, R.L., and Steuver, J.W. (1992) Performance of Active Noise Reduction Headsets, in Noise Induced Hearing Loss, Dancer, Henderson, Salvi, and Hamernik, (Eds) Mosby Year Book, Inc., pp. 389-400, 1992.

KEYWORDS: Auditory Models, Neural Networks, Noise Reduction, Audio Technology, Speech Recognition, Synthesized Speech, 3-Dimensional Audio, Voice Communications, Human-Machine Interaction

AF99-104 TITLE: Adaptive Eye Protection

TECHNOLOGY AREA: Electronics Warfare/Directed Energy Weapons

OBJECTIVE: Develop eye protection that adaptively changes to varying levels of brightness to improve human visual performance over a range of light conditions.

DESCRIPTION: Current eye protection against glare produced by optical sources is an inadequate means of personnel protection where precise human motor functions are required for the job such as piloting, factory work, and outdoor activities. This limitation of current eye protection comes from the fact that optical density is flat across all intensities for the given bandwidth, i.e. bright objects become dimmer but dim objects become undetectable. Safety is compromised by the reduction of visual and situational awareness caused by conventional eye protection. This project will investigate, build and test new technologies to allow adaptive response to varying intensities within a given scene. The new eyewear will be capable of strong reduction of intense objects while allowing dim objects to pass through with little or no attenuation.

PHASE I: The first phase of this effort will be to identify mechanism(s) that support the adaptive eye protection. Phase I will produce a final report describing the physics of the technique and a proposed design for the eye protection. A laboratory demonstration of the technique is required.

PHASE II:Phase II will refine the proposed design from Phase I and build a prototype of the eye protection. Laboratory testing will be conducted on the prototype to demonstrate the adaptive nature of glare reduction. Phase II will include a prototype version of eyewear, lab report of glare reduction tests, and identification of proposed design modifications/improvements for full-scale production.

PHASE III DUAL USE APPLICATIONS: Adaptive glare eye protection has significant commercial applications, especially where intense light and laser light are used. For example, reducing glare to pilots due to the sun and outdoor laser shows not only increases pilot effectiveness, but also increases passenger safety as well. Any outdoor activity can benefit from an adaptive glare reduction over conventional sunglasses since visual acuity will be improved. The ski apparel market is a promising opportunity.

REFERENCES:

1. Van Den Berg, T.J.T.P. On the relation between glare and straylight, Documenta Ophthalmologica, (68): 177-181, 1991.

2. Duntley, S. The visibility of distant object, Journal of the Optical Society of America, (38) 3: 237-249, March 1948.

3. Blackwell, H. Contrast thresholds of the human eye, Journal of the Optical Society of America, (36) 11: 624-643, November 1946.

4. Brennan, D. H. Glare in aviation, Health Physics, (56) 5: 665-669, 1989.

5. Vos, J.J. Disability Glare - A state of the art report, CIE Journal, (3) 2: 39-53, December 1984.

KEYWORDS: Adaptive, Eye Protection, Glare Reduction, Laser Eye Protection

AF99-107 TITLE: Innovative Information Technologies

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop innovative information technologies for enhancing the performance, availability, and affordability of C4I systems and subsystems.

DESCRIPTION: Proposals may address any aspect of Information pervasive technologies not specifically covered by other SBIR topics. Areas of interest include, but are not limited to, innovative concepts and technologies in: Global Awareness, Dynamic Planning and Execution, and Global Information Exchange.

- Global Awareness: Global Awareness entails the affordable operational capability, from local to global level, for all pertinent personnel to understand militarily relevant situations on a consistent basis with the precision needed to accomplish the mission. This understanding is achieved by: exploiting information from Intelligence, Surveillance and Reconnaissance sensor data; examining open source and commercial data, including data provided by other government agencies, that is required for the entire spectrum of military operations. The information is then fused to support Dynamic Planning and Execution, via the Global Information Exchange distribution system. The knowledge, information and data will then be archived in the Global Information Base for continued use and historical analysis. The technologies required to achieve this capability in an affordable military system, including appropriate access mechanisms for our coalition partners, will be developed and transitioned under this thrust.

Information Exploitation
- Image/Video/Text
- Signals

Information Fusion
- Algorithms

Multi-Sensor Collaboration

Global Information Base

Management and Control

Active Information Systems

Precision Distribution

- Dynamic Planning and Execution: This thrust concentrates on the aerospace commanderís ability to rapidly acquire and exploit superior, consistent knowledge of the battlespace, through a worldwide distributed decision-making infrastructure of virtual battlestaffs and intelligent information specialists.

Next Generation C2

Configurable Aerospace Command Center

Time Critical C2

Real-Time Sensor-to-Shooter Operations

Targeting

Joint/Combined Coalition C2

Collaboration/Simulation/Visualization

Aerospace Integration

- Global Information Exchange: Global Information Exchange is the ability to interconnect all members of the Air Force via a netted communication and information system, available anywhere, at any time, and for any task or mission. The ability to communicate by moving raw and processed information throughout a global communications grid is fundamental to Command and Control. Inherent in this capability is the idea of universal information availability across different transmission media with different characteristics. The Air Force's information network must have global reach for its normal day-to-day operations as well as the capability to allow an instant surge of connectivity and capacity into a localized theater for mobile and fixed-site users.

Global Communications

Multiband/Multifunction Communication

Robust Tactical/Mobile/Wireless Networks

RF Communications Systems

Defensive Information Warfare

Information Systems Protection

Attack Detection

Computer Forensics

Secure Computing

Information Systems and Networking

Distributed/Adaptive/Mobile Computing

Adaptive Systems

Survivable Systems

System Architecture

Design and Evolution

PHASE I: Provide a report describing the proposed concept in detail and show its viability and feasibility.

PHASE II:Fabricate and demonstrate a prototype device, subsystem, or software program.

PHASE III DUAL USE APPLICATIONS: Many Information Technologies have substantial dual-use potential and will impact competitiveness and performance of the commercial sector as well as the military sector. All solutions proposed must have potential for use/application in the commercial as well as military sector, and potential commercial applications must be discussed in the proposal.

KEYWORDS: Computers, Intelligence, Communications, Global Awareness, Command and Control, Information Technology, Global Information Exchange, Dynamic Planning and Execution

AF99-108 TITLE: Threat Prediction Fusion

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Development of innovative approaches to data fusion that support the threat prediction.

DESCRIPTION: Data Fusion has been defined (Joint Directors of Laboratories (JDL), Technology Panel on C3 (TPC3), Data Fusion SubPanel (DFSP)) as: "Information processing that deals with the association, correlation, and combination of data and information from single and multiple sources to achieve refined position and identity estimation, complete and timely assessments of situations and threats, and their significance in the context of mission operation. The process is characterized by continuous refinement of its estimates and assessments, and by evaluation of the need for additional sources, or modification of the process itself, to achieve improved results." There are four current functional levels of data fusion: Object Refinement, Situation Refinement, Threat Refinement, and Process Refinement. This SBIR addresses Level-3, Threat Refinement data fusion functionality.

The JDL DFSP has defined Level-3 processing as: Level-3, Threat Refinement develops a threat oriented perspective of the data to estimate enemy capabilities, identify threat opportunities, estimate enemy intent, and determine levels of danger. Key functions include: (1) capability estimation, (2) predict enemy intent, (3) identify threat opportunities, (4) offensive/defensive analysis, and (5) multi-perspective assessment. Current data fusion techniques that support Threat Refinement are very limited. Theoretical solutions exist that support prediction of kinematic data (e.g., tracking), which basically is predicting the next location of an object (i.e., where it is), but very little work has addressed the more abstract requirement of why is it there, and for what reason is it there. It is the answer to these more abstract questions that is the focus of this topical area, which will address innovative approaches to data fusion that support the threat refinement area, with an emphasis on the threat prediction capabilities.

PHASE I: Phase I will investigate innovative approaches to data fusion that support the threat refinement area, with an emphasis on the threat prediction capabilities. Phase I will result in a detailed plan and prototype software, which demonstrates the feasibility of a potential Phase II effort.

PHASE II:Phase II will design and develop the innovative approaches to data fusion that support the threat refinement area, with an emphasis on the threat prediction capabilities as recommended in Phase I, and then prototype a subset of the design to demonstrate the threat prediction capability.

PHASE III DUAL USE APPLICATIONS: Phase III will fully implement and demonstrate the innovative approaches to data fusion that support the threat refinement area, with an emphasis on the threat prediction capabilities, as recommended in Phase II prototype. This topical area has dual-use potential wherever data from different (or even similar) sources are required for decision making, especially when the impact of the current situation needs to be addressed. Examples of potential industries include: drug enforcement and drug interdiction.

KEYWORDS: Data Fusion, Sensor Fusion, Threat Prediction, Threat Refinement

AF99-109 TITLE: Measures of Effectiveness for Abstract Data Fusion

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Development of innovative measures of effectiveness for high level data fusion.

DESCRIPTION: Data Fusion has been defined (Joint Directors of Laboratories (JDL), Technology Panel on C3 (TPC3), Data Fusion SubPanel (DFSP)) as: "Information processing that deals with the association, correlation, and combination of data and information from single and multiple sources to achieve refined position and identity estimation, complete and timely assessments of situations and threats, and their significance in the context of mission operation. The process is characterized by continuous refinement of its estimates and assessments, and by evaluation of the need for additional sources, or modification of the process itself, to achieve improved results." Current data fusion techniques beyond Level-1(correlation) are mainly manual and cannot keep pace with the highly mobile, dynamic forces likely to be faced in the future. New approaches to data fusion levels (2,3, and 4) are being developed/implemented, but there is an obvious lack of metrics available to evaluate the effectiveness of these more abstract data fusion levels, even though a plethora of metrics exist to support Level-1 data fusion. This topical area will address innovative measures of effectiveness to support the evaluation of Levels 2,3, and 4 data fusion.

PHASE I: Phase I will investigate innovative measures of effectiveness that can be utilized to support higher levels of data fusion. Phase I will result in a detailed plan and prototype software, which demonstrates the feasibility of a potential Phase II effort.

PHASE II:Phase II will design and develop the innovative measures of effectiveness which can be utilized to support higher levels of data fusion as recommended in Phase I, and then prototype a subset of the design to demonstrate the validity of the measures of effectiveness.

PHASE III DUAL USE APPLICATIONS: Phase III will fully implement and demonstrate the innovative measures of effectiveness which can be utilized to support higher levels of data fusion, as recommended in Phase II prototype. This topical area has dual-use potential wherever data from different (or even similar) sources are required for decision making, especially when multiple solutions need to be evaluated. Examples of potential industries include: drug enforcement and drug interdiction.

KEYWORDS: Data Fusion, Sensor Fusion, Measures of Merit (MOM), Measures of Performance (MOP), Measures of Effectiveness (MOE)

AF99-110 TITLE: High Throughput Volumetric Memories

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Identify and characterize candidate media, optoelectronic system architectures, or other write/read concepts to provide storage capacities of at least 1 Terabit/cm3 (or at least 30 Gigabit/cm2) and throughput rates of a Gigabit per second. In addition, to identify and characterize hardware and software to perform advanced database management tasks such as associative retrieval for data correlation and fusion, as well as allow successful integration of various volumetric memories into single and multiprocessor network architectures.

DESCRIPTION: The advent of optoelectronic computing and highly parallel electronic processing necessitates storage systems with enormous capacity and bandwidth. Meeting this demand with current technologies results in storage systems that dominate processors in terms of overall cost, power consumption, volume and weight. Recognizing these and other problems inherent to high data rate, high density data storage and associative retrieval, the Air Force Research Lab Information Directorate is investigating erasable optical disk and multi-dimensional volumetric memory technologies. These technologies offer great promise due to their high data densities and their inherent parallelism in recording and readout, but in order to take full advantage of this, data transport systems must be designed to successfully integrate these mass storage systems with existing computer networks, with minimal data bottlenecking and latency.

This effort seeks to exploit the recent advances made in the field of nano-technology in order to increase bit storage density to at least 1 Tb/cm3. Organic polymers, synthetic DNA, and covalent transition metal compounds all have shown the potential to increase storage densities by orders of magnitude. The challenge is to fabricate them on a nano-scale and then address (write/read) them at room temperature. It is projected that these systems will yield aggregate data rates on the order of 1-10 Gb/s.

These extremely high bit densities and data rates however, necessitate a totally innovative search paradigm for accurately minimizing latency times. The development of associative retrieval algorithms will insure that data is transported within a cognitive bandwidth, i.e., minimum information needed to identify and/or understand data.

Another area of growing interest involves optimally utilizing these inherently parallel memories in traditional serial network scenarios. This should be done in a way that maximizes the net throughput rate to all users, while minimizing system complexity. The problem can be broken up into three different areas. First, hardware issues are of great interest. Traditional electronic transmission lines may not work well at these data rates. Fiber optics have shown a lot of promise in this area, as shown by the newly designed HIPPI-6400 standards. Additionally, modulators and detectors designed to allow one to one imaging would simplify the optical design of memory systems. Free space optics may be a long term solution as well, not only for their very high data bandwidth, but also since they can be used for parallel processing applications. Second, software issues become critical in terms of manipulating these large pages of data. Tied closely to this are data protocol issues. This includes optimizing the parallel-to-serial conversion to minimize data bottlenecking, finding the optimal block size to perform error corrections, selecting optimal page sizes, etc.

PHASE I: Consists of concept definition with experimentation adequate for feasibility demonstration.

PHASE II:Would consist of the design, fabrication, and testing of a brassboard.

PHASE III DUAL USE APPLICATIONS: Would involve the generation and implementation of marketing plans for commercializing the technology developed under Phase I and II. High density mass storage would impact every business from entertainment to medicine. Imagine 4000 hours of audio, or all the X-Ray films of a large metropolitan hospital, stored on a device the size of a sugar cube. The development of this technology would benefit users from the Library of Congress to the records department of insurance companies.

KEYWORDS: Fiber Optics, Nanotechnology, Organic Polymers, Volumetric Memories, Associative Retrieval, Page Oriented Memories, Spatial Light Modulators

AF99-111 TITLE: Computer Forensics

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Development of computer analytic techniques and a forensics toolkit for use by computer forensics examiners. This work will focus on development of technology for the detailed evaluation and in-depth analysis of data related to computer crime, unauthorized computer use, and military and industrial espionage activity.

DESCRIPTION: Classically, computer forensics is a narrowly defined technology area focusing solely on the process of evidence extraction from computer media that has been seized by law enforcement authorities as part of an investigation into illegal or criminal activities. We, however, view computer forensics as encompassing a broader area of technology which includes processes from both the Detect and React paradigms of the broader information assurance technology area. In that context, computer forensics is an emerging technology that is concerned with a continuum of activities spanning the spectrum from the collection of audit and intrusion data to classic evidence reconstruction for legal purposes. Forensics, therefore, includes intrusion detection data gathering, assessing damage resulting from information attacks, locating hidden and disguised files, and data recovery from malicious (as opposed to) inadvertent destructive activity. In addition to the traditional tools used by computer forensics examiners, other tools such as intrusion-detection tools, computer auditing tools, and network management tools provide additional relevant evidence and information.

A purely military application for this technology could be automated rapid exploitation of data contained in adversary computers seized during swift military operations. The work will address the reconstruction of evidence from computers where the data/files have been intentionally or maliciously destroyed or modified for the purpose of concealing an illegal activity. Other conditions under which forensics tools could provide assistance are detection of modified system binaries, identification of malicious programs, discovering indications of sniffer activity on a specific system, and identification of various foul play indicators such as modified system logs and "backdoors". Technologies sought under this program include: techniques for handling password-protected files; methods for locating and decrypting of encrypted files; procedures for uncovering data hidden within seemingly innocuous data (steganography); tools for searching for hidden and disguised files, file filters for reducing both the search space and time for forensics investigation of large media; tools for maintaining the integrity of the forensics process while managing the forensics workflow. All of these tools should be interoperable and accessible through a common user-friendly interface.

PHASE I: Develop and prototype techniques that address existing deficiencies in computer forensics. Specific technology areas to be investigated include: rapid discovery of evidentiary information, decryption, steganography identification and recovery, password protected file discovery and bypass, data integration from various evidentiary sources, and verifiable forensics workflow management. The products of this phase should be a system architecture and/or proof of concept demonstrations.

PHASE II:Build and test the system architecture specified in Phase I.

PHASE III DUAL USE APPLICATIONS: The Air Force needs computer forensics technology in order to maintain its complex, large-scale information systems and networks in a continuous operational state. Also, the Air Force requires this technology to provide automated support for the damage assessment data recovery functions which are invoked as a result of successful penetrations by adversaries. As a result of the current movement to electronic commerce environments, (i.e., the Internet, World Wide Web and corporate Intranets) the business and industrial sectors require strong and reliable computer forensics technology to mitigate the effects of the increased exposure and vulnerability of their information assets to malicious attack from the outside as well as misuse by disgruntled insiders. The commercial sector needs this technology to maintain customer confidence in the integrity of its transactions and financial data.

REFERENCES:
1. Clark, F. et. al., "Investigating Computer Crime (CRC Series in Practical Aspects of Criminal and Forensic Investigations)"
2. Icove D. et. al., "Computer Crime: A Crimefighter's Handbook"

KEYWORDS: Auditing, Computer Forensics, Information Systems, Intrusion Detection

AF99-112 TITLE: Communication Performance Measurement for the Mobile User

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop an affordable product for system-independent mobile Information Technology (IT) performance measurement.

DESCRIPTION: Mobile users of high-frequency (HF) radio and Satellite service are at a disadvantage due to limited access bandwidth to packet services such as the Internet. An efficient mobile capability, independent of the IT system providing communication services, is required to measure user-oriented performance. Parameter measurement is required to establish a performance baseline and to provide an input to an independent audit log for service record of packet delays and data transfer service losses for mobile nodes. Time stamp logging at the critical mobile end-user interface is required for determination of network throughput and latency. Timestamp consistency is typically provided by using global positioning system (GPS)-based Network Time Protocol (NTP) but accuracy of current timestamps is marginal. In theory, unidirectional delays can be measured accurately using the global positioning system (GPS) receivers but this can be expensive. Therefore, innovation in developing compact, lightweight and accurate timestamping techniques is required. This capability will also be useful in the validation/verification of simulation results and in validation of digital telecommunication services quality of service (QoS) data.

PHASE I: Design and demonstrate the feasibility of a low-cost unidirectional measurement capability.

PHASE II:Fabricate a mobile measurement product based on the techniques developed in Phase I. Demonstrate the effectiveness of these techniques.

PHASE III DUAL USE APPLICATIONS: This technology is widely applicable to both military and commercial mobile information technology systems. An affordable tool for the measurement of mobile IT performance would be used both by independent cellular providers as well as by developers and integrators of military mobile wireless communications systems.

REFERENCES:

1. T.J. Kostas et al., ìReal-Time Voice Over Packet-Switched Networksî, IEEE Network Mag., January/February 1998
2. D.L. Mills, ìNetwork Time Protocol (Version 3), Specification, Implementation and Analysisî, RFC 1305, March 1992

KEYWORDS: User-Oriented, Mobile Communications, Performance Measurement

AF99-113 TITLE: Internet Protocol (IP) over Asynchronous Transfer Mode (ATM) through Narrowband Common Data Link (CDL)

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Investigate technologies and techniques required to perform standard IP-based inter-networking through a CDL narrowband link. This includes the design of protocols for implementing IP-based services (FTP, TCP, UDP) through the user channels of reconnaissance data links such as the Common Data Link (CDL) narrowband link.

DESCRIPTION: Initially, the relevance and application of existing RFCs as related to the implementation of CDL and the use of IP over synchronous error-prone links, including Reliable Multicasting Datagram Protocol (RMDP) and IP over ATM (RFC 1577). Research would then be conducted to collect performance data to determine the most suitable implementation parameters for the link. Emerging network technologies would also be thoroughly evaluated to determine the optimum implementation for CDL (ATM, Fast Ethernet, Gigabit Ethernet or IEEE 1394/Firewire). Different physical networks could be used on the airborne and the surface systems, i.e., ATM on the platform and Fast Ethernet on the ground. Large cost savings could be realized due to the commodity nature of these COTS products. In addition, a standardized interface will allow commercial network users to include the asymmetric multiplexing capabilities of this system into their commercial products (computers, routers, switches, etc).

PHASE I: Investigate the use of RFCs for application in CDL data links. Research the performance to determine the most suitable implementation parameters for the data link. Evaluate the related emerging technologies for application to data links such as CDL.

PHASE II:Develop software for a CDL Multiplexer/Demultiplexer (MDM) to enable IP-based communication through the MDM. Integrate commercial ATM interfaces into a CDL system. Implement Microsoft Peer Web Services (a web server) in the airborne platform as a means for delivering telemetry status to the ground user, receiving commands from the ground, and providing situational awareness to a terrestrial C3I network. Distribute video data directly to the terrestrial network from the platform using broadcast UDP. Develop a CDL-Internet Gateway, which will allow a CDL user to access the civilian Internet. Demonstrate the application of the CDL-Internet Gateway capabilities by having a simulated platform pilot (of a Guardrail) access the civilian Internet to obtain a weather update and to buy a book on landing a plane. Develop software to allow existing CDL data link terminals to demonstrate asymmetric (200 kbps/10.71Mbps) and symmetric (10.71Mbps) Line-of-Sight (LOS) Virtual LAN service to connect geographically diverse C3I LANs via LOS links. Develop software and hardware to improve LOS to a 45 Mbps symmetric link with Reed Solomon forward error correction coding. Develop capability for LOS Virtual LAN service through a Ku-band satellite link by demonstrating ability to provide forward and return link at reduced bit rates compatible with current commercial satellite transponders.

PHASE III DUAL USE APPLICATIONS: The technologies developed would allow the communications between and among diverse data terminals with minimal interface adjustment considerations.

KEYWORDS: Ethernet, Internet Protocol, Local Area Network, Asynchronous Transfer Mode

AF99-114 TITLE: Distributed Collaborative Modeling and Simulation

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop and demonstrate collaborative simulation, analysis, and visualization technologies to support a distributed engineering environment.

DESCRIPTION: The contractor shall research, develop and demonstrate innovative constructive and virtual simulation technologies that support the overall concepts of the collaborative engineering environment and distributed simulation networking. Maximum use of commercial-off-the-shelf desktop, workstations, and distributed simulation technologies shall be employed to provide a virtual engineering development environment so that integrated information concepts can be evaluated in a realistic operational combat-like environment. Research from this effort shall play a critical role in the rapid cost effective development of weapon systems. Technologies developed shall provide characterizations, performance data, life-cycle cost information to assess mission benefits, generate designs and implementations, and/or generate Cost of Function and Measure of Effectiveness estimates. The following technical areas are of major concern:
a. Off-board and on-board sensor modeling
b. Data collection and analysis, and configuration control
c. Standard Query Language (SQL) compatible data base management system product/process models
d. Visualization of simulation scene, mission profile, simulation parameters and weapon system performance
e. Distributed simulation networking concepts
f. Affordability and cost modeling

PHASE I: The desired products of Phase I are 1) identification of the enabling realtime or non-realtime technologies for modeling and simulation, 2) conduct of specific experiments to verify critical aspects of the defined concepts, 3) development of a system specification, implementation approach, and demonstration plan. The contractor shall also document the potential for a Phase II follow-on effort.

PHASE II: Accomplish a detailed design, develop the prototype technology and demonstrate the proposed technology in the appropriate Information Directorate simulation facility. The contractor shall also detail his plan for his Phase III effort.

PHASE III DUAL USE APPLICATIONS: The desired product of Phase III is a robust M&S capability for use in defense and commercial information and sensor technology development. M&S is an enabling technology and a change in the way of doing business that will have major implications for the commercial and defense sector. The commercial marketplace is presently making greater use of generic simulation techniques, simulation infrastructure, and off-the-shelf components for applications in financial industries, manufacturing, industrial process control, biotechnology, healthcare, communication and information systems. The aircraft and automotive industries have demonstrated the success of integrated computer assisted design with supporting modeling and simulation to bring products to market quickly. Advances in software and computer technology are making virtual prototyping possible and affordable for the small to medium business. Software development itself is a manpower intensive endeavor. Requirements definition remains a problem area where the user is unable to verbalize what he/she wants in detail. Virtual prototyping of software requirements and modeling of the software is a future growth area in which simulation is used to review completeness of software requirements and functionality.

KEYWORDS: Data Analysis, Data Collection, Realtime Simulation, Modeling and Simulation, High Level Architecture, Collaborative Engineering, Collaborative Virtual Prototyping, Distributed Interactive Simulation

AF99-115 TITLE: Multiple Simultaneous User Interface Technologies For C4I Systems

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop multiple simultaneous human-computer interfaces (HCI) utilizing non-standard computer input devices.

DESCRIPTION: The increasingly complex battlefield environment drives the requirement for the presentation and interactive control of the endless stream of information arriving from a combination of sensors deployed on a variety of platforms. The military commander and his staff are provided an enormous amount of information to interact with and disseminate. Today's command center consists of a commander directing multiple operators who have one-to-one interaction with the information processing software, either at individual workstations or collectively on large screen displays.

The display and manipulation of real-time multimedia data in a battlefield operations control center requires multiple user interaction, i.e. more than one operator needs access to a variety of information processing software at any given time. The interaction must be real-time to support critical decision-making time frames of the military commander.

Current computer systems are limited to a single input device (standard mouse and/or keyboard) controlled by a single operator. Alternative input devices such as voice recognition software and laser pen/pointer devices suffer the same limitations as the traditional keyboard/mouse combination. The need to allow multiple operators to simultaneously interact with a large high-resolution display hosting information processing/presentation software via non-traditional input devices is the main objective of this effort. All solutions must be DII COE compliant and based on COTS products, either commercially available within one year or under development for near term product release (under two years).

PHASE I: Identify current limitations of HCI technology and input devices that prevent multiple simultaneous use of the traditional keyboard/mouse and speech/laser pen input devices. Research and identify actual innovative techniques to overcome the single user/single input device, using commercial and university research and development programs as the subject of the study. Provide recommendations, alternatives, and a feasibility demonstration of candidate technologies. All technology candidates should have minimized cost and physical dimensions and be DII COE compliant.

PHASE II: Phase II shall accomplish a prototype development and/or demonstration of multiple simultaneous HCIs utilizing traditional keyboard/mouse and speech/laser pen input devices.

PHASE III DUAL USE APPLICATIONS: The capability to have simultaneous control of computer software applications by multiple users will allow for interactions never before possible. It could be useful in air traffic control, medical training and classroom distance learning where multiple user access to the same data or display is required.

KEYWORDS: Human-Computer Interfaces, Multimedia Data Display and Control, Non-Traditional Computer Input Technologies

AF99-116 TITLE: Mixed-Resolution Modeling of Command and Control

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop techniques for modeling command and control scenarios composed of entities at various levels of detail/complexity.

DESCRIPTION: Assessment of the combat worthiness of C4ISR techniques, equipment and doctrine involves the construction of large-scale simulations, often comprised of components that vary widely in scope and/or complexity. Traditional synthesis efforts have taken a "locate and integrate" approach, whereby disparate models are coupled (for example, the outputs of a more detailed model are often passed as performance measures to broader-scope simulations) with little thought as to whether or not these couplings are "valid." There is much research required to validate -- or invalidate -- these traditional approaches (e.g., Lanchester Equations), and to set the stage for appropriate (i.e., logically/physically valid) reuse of legacy models and data.

PHASE I: Perform preliminary investigations of JSIMS, JWARS, NASM, Next Generation Mission Model (NGMM) and EADSIM as they relate to Mixed-Resolution Modeling and model/data interoperability. Develop an approach for improved MRM modeling, both in a general sense and in specific detail, for one of the above listed systems.

PHASE II: Accomplish a detailed design, develop a prototype mixed-resolution modeling formalism, and demonstrate the proposed technology in the appropriate Information Directorate simulation facility. The contractor shall also detail his plan for his Phase III effort.

PHASE III DUAL USE APPLICATIONS: The desired product of Phase III is an advanced technology demonstration of the worthiness of MRM techniques in complex combat simulations. Great opportunities exist for combining the benefits of formal theory and computational experimentation towards increasing realism in large scale simulation; in any domain.

KEYWORDS: JWARS, Aggregation, Model Abstraction, Command and Control, Lanchester Equations, Mixed Resolution Modeling, Variable Resolution Modeling

AF99-117 TITLE: Time Critical Command and Control (C2)

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop and demonstrate a new generation of technologies and tools for situation analysis, planning, resource allocation and execution monitoring in near real time.

DESCRIPTION: Develop and demonstrate a new generation of situation analysis, planning, resource allocation, and execution monitoring technology that will enable in-time engagement of critical targets across a spectrum of time-critical missions from time-phased attack of fixed (e.g. factory) and moving (e.g. tank column) targets, to the real-time use of hunter-controller-killer assets against short exposure time targets (e.g. transporter-erector-launcher). Central to this program is a core of technology developments that will enable a rapid, proactive, interleaved planning and execution monitoring capability with an emphasis to reduce the time to provide dynamic, distributed, continuous, planning, assessment and re-planning capabilities linking Campaign, Force, Mission and Engagement echelons C2 operations. Also needed is the capability to skip echelon, e.g.

Campaign level to a "shooter" or "mover" at Engagement level, while informing elements at the Mission and Force echelon levels. In developing a theater air campaign plan for future regional conflicts, a planning staff will need to take into consideration the influences of other members of the coalition force. The influences include differing Rules Of Engagement (ROE), "offensive" assignments, differing military subordination, and authority roles. What is needed is a planning system that is designed for use with coalition forces. Such a system should be adaptable to differing coalition force structures. Mixed-initiative planning should include the capability to transcend language and cultural barriers. The response to future crisis will need to occur more rapidly than ever before. Part of this response will include planning by a commander and his/her staff while en route to a theater of operations. This requires a planning capability that is extremely portable, yet powerful enough to take advantage of multiple knowledge and data sources while in flight. Such a system, for example, a lightweight, portable COTS based solution that implements a knowledge based planning system that can be used in an airborne environment for rapid crisis response supporting multi-national coalition forces, is required to analyze information to determine strategies, collaborate with both forward and rear Air Operations Centers (AOC), and build/modify plans in response to events in the environment. This effort should provide the United States the capability to project sufficient power rapidly, seize the initiative in the early stages of a major conflict. Provide commanders with rapid, responsive and reliable options to deter conflict or make the difference between a quick, efficient victory and a protracted, costly engagement.

PHASE I: Perform preliminary investigation into technologies and tools that are capable of meeting the objective of this effort. The solution should use standards-based, commercial-off-the shelf (COTS), Geographic Information System (GIS) and client/server software (i.e. Web server and browser) and be capable of supporting the entire spectrum of operations. Cost, benefit, risk, portability for use en route to a theater and other related technical concerns shall be addressed.

PHASE II:Develop and demonstrate the prototype tool(s) or technologies on a feasible scenario appropriate for both military and commercial applications. For example, real-time route planning for Air Force aircraft during conflict and commercial package carriers (e.g. Fed Ex). Metrics such as time to complete task, completeness of the result, level of uncertainty and others shall be documented showing increased capability over existing systems and capabilities.

PHASE III DUAL USE APPLICATIONS: Information-Intensive interactions between computational nodes on the network is defined as network-centric operations. Whether these interactions are focused on commerce, education, or military operations, there is "value" that is derived from the content, quality, and timeliness of information moving between nodes on the network. This value increases as information moves toward 100% relevant content, 100% accuracy, and zero time delay toward information superiority. Tools and technologies developed by this effort will have significant impact on industry as well as the military.

KEYWORDS: Real Time, Uncertainty, Coalition Forces, En-Route Planning, Rules Of Engagement, Execution Monitoring, Knowledge Based Planning, Knowledge Based Software

AF99-119 TITLE: Tools and Techniques for Advanced Knowledge Discovery

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop a new generation of Knowledge Discovery and Data Mining tools for intelligent, automated data/knowledge discovery. It is envisioned that an advanced Knowledge Discovery system could draw upon algorithms, methods, and techniques from a number of fields including (but not limited to) machine learning, pattern recognition, knowledge acquisition/extraction, artificial intelligence, databases (data warehousing) and statistics.

DESCRIPTION: The capability to collect and store data has far outpaced our capabilities to make use of that data. While efficient storage and lookup tools abound, the ability to analyze and interpret these large bodies of data/knowledge is still lacking. A new generation of tools and techniques to automatically and intelligently assist humans in finding useful knowledge from this data is needed. For the purposes of this solicitation, knowledge discovery is referred to as the OVERALL process of discovering useful knowledge from data. This process will include steps for data selection/sampling, preprocessing, transformation, data mining, postprocessing, and interpretation/evaluation of the discovered patterns into knowledge. The Data Mining step, applying algorithms to extract patterns from data, is an important step in the knowledge discovery process. While proposals for advanced data mining techniques will be considered, those focusing more on other portions of the overall Knowledge Discovery process will be given preference. Much has been done (and is being done) commercially in the area of data mining and should be leveraged to the greatest extent possible.

PHASE I: Identify, investigate, and prototype an advanced knowledge discovery capability and identify potential Air Force and commercial users of these products.

PHASE II:Develop and demonstrate a unique large-scale knowledge discovery capability in both Air Force and commercial domains.

PHASE III DUAL USE APPLICATIONS: This technology could have a major impact on any military or commercial application that could benefit from intelligent analysis and interpretation of large amounts of data. Some of these include: sales, health care, fraud detection, astronomy, biology, weather, nuclear power plant control, decision support systems, and military command and control.

REFERENCES:
1. Usama M. Fayyad, Gregory Piatetsky-Shapiro, Padhaic Smyth, and Ramasamy Uthurusamy, Advances in Knowledge Discovery and Data Mining, Published by the AAAI Press / The MIT Press, ISBN 0-262-56097-6, 1996.
2. W. Frawley and G. Piatetsky-Shapiro and C. Matheus, Knowledge Discovery in Databases: An Overview. AI Magazine, Fall 1992.

KEYWORDS: Databases, Data Mining, Machine Learning, Pattern Recognition, Artificial Intelligence, Knowledge Acquisition/Extraction

AF99-121 TITLE: Intrusion Detection And Monitoring Of Large-Scale Networks

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop a real-time common operating picture of the information infrastructure that enables timely response to network faults, IW attacks, and will decrease the manpower and expertise required.

DESCRIPTION: The advent of broadband communications deployed with fiber, wireless, fixed and mobile assets has enabled the establishment of decentralized and distributed information systems that support large numbers of users simultaneously. It is critical that a common operating picture of the information infrastructure be developed that addresses both the health and security posture of the network. This common operating picture will provide commanders a readiness indicator of communication, network, and computer resources that are required to carry out todayís Intelligence, Planning, Execution, Assessment, and Logistics functions. The fused picture of the information battle space will also permit early Indications and Warnings (I&W) of imminent Information Warfare (IW) attacks, and a coordinated assessment and containment of the attack afterwards. These capabilities will be realized by the fusion of network management information to hierarchical or centralized organizations to achieve real-time network management and control simultaneously for Unclassified, Secret, NATO/Coalition, and Top Secret (with compartments). This will be accomplished through the use of standards-based management platforms, intrusion detection systems, and high-assurance network boundary devices such as guards, firewalls, and secure object brokers.

PHASE I: Investigate resource allocation and apportionment mechanisms to control execution of tasks in an object oriented distributed computing system. Investigate and identify multi-level Network Management Systems mechanisms that operate in a cooperative manner to provide hierarchical, peer-to-peer, summary level, and component level network management across multiple user domains. Mechanisms should consider available information system resources (processing, storage), available communication network resources (bandwidth) and user requirements (deadlines, level of effort, scope, security, etc.).

PHASE II:Construct monitoring and management mechanisms at the information system and communication network layers that interpret the current environment state and execute changes to the information system and network to accommodate given user tasks and requirements.

PHASE III DUAL USE APPLICATIONS: The developed mechanisms will provide monitoring and management for Distributed Information Infrastructure(s) and provide a common operating picture, with reduced manning and logistics for deployed military Command and Control resources. This technology also has broad application to the telephony and data communications industries who provide information system and communication network services.

REFERENCES:
1 - T. Yang, Performance Analysis on Distributed Network Management System, IEEE 1996
2 - A. Franceshi, L. Kormann, C. Westphall, ìPerformance Evaluation for Proactive Network Management, IEEE 1996
3 - Hood, C. and C. Ji, ìProactive Network Fault Detection, Proceedings of IEEE INFOCOM, 1149-57, Kobe, Japan, March 1997.

KEYWORDS: Network Management, Information Systems, Distributed Systems

AF99-122 TITLE: Dynamic Data Intensive Intelligent Technology

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop adaptive data intensive techniques that are capable of dynamically manipulating, filtering, aggregating, and managing large amounts of data according to specific usage/function, in commodity form/blocks, for rapid integrated access to large amounts of multiple information sources dynamically structured using intelligent (re)configurable memory management techniques.

DESCRIPTION: The approach will be development of techniques to export information about data structures and access patterns from a database. Intelligence "wandering through memory" will lead to very large information stores organized around thousands of DRAM chips which will dynamically (re)configure according to function. Techniques such as data aggregation/dissemination, prefetching data, restructuring data based on locality and rapid fetching of data from main memory will be used to configure dynamic data/knowledge processing. Adaptive memory techniques in conjunction with advanced data structures could provide innovative ways to both access and store various forms of data/knowledge. In the past data repositories (databases) were viewed as static stores of information that had to be identified, retrieved, and sent to a central analysis process. The data intensive paradigm is that the data stays in place, and the analysis processes come to the data. Techniques are needed to provide ways data should be dynamically structured and stored for efficient retrieval as well as provide adaptable transformation techniques to structure knowledge which can be managed more efficiently so that information can be automatically filtered, manipulated and summarized. The ability to efficiently develop such configurable intelligent data systems relies significantly on the development of new concepts for transforming functions into dynamic processes that automate and improve how to integrate and analyze information, make decisions under uncertainty and communicate knowledge. The result will dramatically improve data access capability within computing environments and perform situation analysis of relevant data and/or information/knowledge. Experiments will be designed to demonstrate the relevance of the technology to Global Awareness as recommended by New World Vistas. These experiments will also enable measurement, comparison and evaluation of competing designs to support joint data intensive efforts of DARPA and the Infomation Directorate of the Air Force Research Laboratory.

Mechanisms to be investigated include (1) intelligent information technology using (re)configurable logic blocks/chips, (2) adaptable memory design/configurations, (3) electro/optical special purpose architecture enhancements, (4) dynamic intelligent special purpose function architectures and (5) evolvable data/knowledge base configurations for scaleable information aggregation/processing. Technical challenges include unique use of adaptive architectures, dynamic databases, and information integration.

PHASE I: Will investigate development of techniques for designing, developing and integrating large-scale dynamic data intensive information systems

PHASE II:Will demonstrate a dynamic adaptable data/knowledge base configuration utilizing a an intelligent data intensive paradigm for an appropriate scaleable information processing domain/platform.

PHASE III DUAL USE APPLICATIONS: Will test dynamic data intensive tools for dynamic (re)configurable knowledge base access and commercialize results of Phase I and II. Rapid accessibility to integrated systems and information increases choices for consumers in both civilian and defense applications. This technology could have a major impact on applications that require integrated decision making and timely and accurate information such as planning/scheduling systems, autonomous vehicles, aircraft operation, hospital life support systems, decision support systems and personal military command and control.

KEYWORDS: Software, Dynamic Data Base, Adaptive Computers, Data/Knowledge Base, Intelligent Systems, Reconfigurable Computing

AF99-123 TITLE: Flexible Information Extraction Learning Algorithm

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop and demonstrate automated statistical natural language learning algorithms that learn by example to extract multiple relationships and complex events from free text message traffic.

DESCRIPTION: Statistical learning algorithms are a new "cutting edge" approach to information extraction (IE), but to date they are only capable of shallow extraction of named entities and shallow events. This research will develop the hierarchical models and various techniques to perform "deep" levels of IE. This work includes determining when multiple relationships are expressed in a single phrase or sentence, and when the same event is described in several different places in text. Previous IE techniques have involved the use of rule-based technology, which has been ineffective at deep event-level IE.

The payoff of this research will be a substantial reduction in the time it takes an intelligence analyst to process message traffic and update his or her data bases. The result of this work will be software that can be tailored to different domains to be utilized to perform free text extraction for the Intelligence Data Handling System (IDHS). The work also has direct applicability to the Intelligent Analyst Associate (IAA) work being performed for NAIC, the JIVA program, the National Ground Intelligence Center (NGIC) PATHFINDER program, and DARPA's TIPSTER program.

PHASE I: Develop a model of the range of possible interrelationships between named entities. The learning algorithm will be used to control the ways these different elements can be combined to produce an event. A prototype will be developed to demonstrate the feasibility of extracting multiple relationships from free text.

PHASE II:Enhance the statistical learning algorithm developed in Phase I to extract complex information extraction events of the form "Who" did "What", to "Whom", "When" and "Where" .

PHASE III DUAL USE APPLICATIONS: The results of this effort will be an enormous contribution to the IDHS and other Air Force and DoD programs that are required to manually process free-text messages. The effort also has direct commercial applicability to commercial banking, medical, and insurance establishments that are required to process textual forms.

KEYWORDS: Natural Language, Information Extraction, Statistical Learning Algorithm

AF99-124 TITLE: Improved Response to Time Critical Targets

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop technology to provide automated intelligence preparation of the Battlespace. It must allow for collaborative product analysis, exploitation, validation and dissemination. It must perform consolidation and reporting, in near real time of information from a multitude of dissimilar sensors (radar, intelligence, ESM, etc.) to provide a common tactical picture and common operational picture.

DESCRIPTION: State-of-the-art Intelligence Preparation of the Battlespace (IPB) is required to effectively prosecute time critical targets. Currently, the Air Force is developing a methodology and software tools for the development and application of computer-based IPB. However, the AF is not capable of accomplishing the required processes and products associated with IPB due to lack of primary data from the intelligence production process and from the NIMA map data production process. Both the Intelligence production process and the NIMA map data production process are highly labor-intensive which seriously limits the amount that can be produced. The data requirements for IPB require extensive current data which can not be produced by the current manual processes, which are outdated. The limited data that is produced today must still be further manually refined by the IPB analysts and operators to make it suitable for field-level use in preparation for, or execution of, a conflict.

Additionally, rapid response to time critical targets (TCTs) requires consolidation and reporting, in near real time, of information from a multitude of dissimilar sensors (radar, intelligence, ESM, etc.). Numerous agencies are independently working on some level of sensor or data fusion, but there is a gap in the USAF's capability to prosecute TCTs, e.g., theater missiles, cruise missiles, etc. The ability to sort through a complex myriad of information from multiple sources and quickly identify potential targets will allow the Air Force and other services to leap forward in the process of addressing this need.

PHASE I: Perform preliminary investigation into the technology required to provide automated Intelligence Preparation of the Battlespace (IPB). The system must produce consistent, uniform, large volume/quantity of high resolution data suitable for detailed IPB terrain analysis and must provide for dynamic IPB data base updates and dissemination. The technology investigated must perform consolidation and reporting, in near real time, of information from a multitude of dissimilar sensors (radar, intelligence, ESM, etc.), to provide a common tactical picture and common operational picture.

PHASE II:Build and demonstrate a state-of-the-art IPB system that will effectively prosecute time critical targets within the associated compressed timelines.

PHASE III DUAL USE APPLICATIONS: The capability to incorporate map and situational data without prior human review and analysis in near real time, and display a common operational picture using this data along with inputs from various types of sensors could be of value in a number of civilian government applications. It could be useful for example for traffic control, particularly in inclement weather; in congested marine areas such as harbors and heavily traveled rivers; it would have applicability in forest fire fighting; and in rescue and relief operations in widespread weather or other natural disasters. It could be used in the civilian sector to expand the capabilities and value of satellite surveillance and the accompanying results.

KEYWORDS: Data Fusion, Sensor Fusion, High Resolution Data, Common Tactical Picture, Common Operational Picture, Intelligence Production Process, Automated Intelligence Preparation

AF99-126 TITLE: Data Classification Algorithms

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop an algorithm for categorizing data points described by multiple parameter measurements.

DESCRIPTION: A data clustering system can be used for detection of anomalous or fraudulent behavior of commercial or military (both friendly and adversarial) assets. Although considerable effort has been applied to the problem of complex pattern recognition, results to date have application within narrow boundaries. The goal of this project is to develop a generic, functional method for creating groups (clusters) of similar data points where the data points are described by specifying several dozen parameter values. Each cluster should contain only those data points which are more similar to each other than to data points contained in any other cluster. A definition of "similar" needs to be developed. This definition might vary depending on the set of data points or the application which will rely upon the data clustering algorithm developed in this project.

PHASE I: Given a large (on the order of tens of thousands) set of data points, each of which has widely-varying values for several dozen parameters, determine what it means for two points to be similar enough to belong to the same classification. Potential solutions may range from simple Euclidean distance computations to neural network simulations. Ground truth classification is available for the large fraction of the data set, but a method that does not rely on development or training against a ground truth data set is highly desirable. Develop an algorithm for creating groups of similar points. Each group (or cluster) would contain a set of points that are more similar to each other than they are to points in other clusters. Furthermore, each cluster should be able to be identified or described in some manner (geometric mean, mode, centered, etc.).

PHASE II:Develop a hardware and/or software system which can create clusters as new points are introduced into the large collection of data. This system should be able to accept a new data point, quickly extract relevant parameters, decide if this new data point should be a part of an existing cluster, or if a new cluster needs to be formed. Subsequently, consider, the where the value of one or more parameters should predetermine to which cluster this new point should belong. However, if the clustering algorithm determines that this point ought to belong to a cluster other than the one predetermined by the selected parameters(s), the system ought to alert the user that there is a discrepancy. Additionally, this system should handle the case where the clustering algorithm might form several distinct clusters from one set of points with the same ground truth cluster identification, that is, a data cluster may be multi-modal.

PHASE III DUAL USE APPLICATIONS: Commercial and military communications organizations would require such a system to detect fraudulent use of their resources. The Internet, Wide Area Networks, Local Area Networks, and personal computers might require such a system to detect illegal attempts to access protected resources. Commercial and military behavior of their equipment.

REFERENCES:

1. ElGayer, N., Ismail, M.A., et al., A Comparative Study Of Different Fuzzy And Conventional Neural Network Models For Data Clustering, Proceedings of EFDAN '96 European Workshop on Fuzzy Decision Analysis for Management, Planning and Optimization, 21-22 May 1996, Dortmund, Germany, p. 19-24. Publisher: Fuzzy Demonstrations-Zentrum Dortmund im ICD Inf. Centrum Dortmund, Germany, 1996 (XX96-02133).
2. Sakar, M. Yegnanarayzna, B., A Clustering Algorithm Using Evolutionary Programming. ICNN 96. The International Conference on Neural Netowrks (Cat. No. 96CH35907), 3-6 June 1996, Washington DC. Part vol. 2, p. 1162-1167, vol. 2, IEEE, New York, NY 1996.
3. Pemmaraju, S., Nitra, S., Clustering Of Noisy Image Data Using An Adaptive Neuro-Fuzzy System, Conference: Intelligent Robots and Computer Vison XO: Biological, Neural Net, and 3-D Methods, November 18, 1992, Boston, MA: Proceedings of SPIE - The International Society for Optical Engineering, Bellingham, WA, v. 1826, p. 327-334, 1993.
4. Murty, M.N., Krisha, G., "A Computationally Efficient Technique For Data-Clustering, " Pattern Recognition, vol. 12, no 3, p. 153-158, 1980.
5. Gala, B.E., A Data Clustering Algorithm For Feature Extraction And Unsupervised Learning, Proceedings Of The Conference On Computer Graphics, Pattern Recognition, And Data Structure, 14-16 May 1975, Los Angeles, CA. IEEE, New York, NY, p. 323-332, 1975.

KEYWORDS: Databases, Data Reduction, Data Clustering, Fraud Detection, Anomaly Detection, Data Classification

AF99-127 TITLE: Adaptive Data Rate Control for Satellite Downlink

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop the necessary technology (Algorithms, Hardware, Software) to integrate Adaptive Data Rate Control into satellite downlink telemetry Radio Frequency Channels.

DESCRIPTION: Satellite downlink data throughput rates, which are currently too low to meet the needs of the global data user community, must be increased. The USAF is currently constrained by bandwidth, satellite transmitter power, and ground segment availability which preclude the recovery of all possible payload data. This results either in lost data or restricted payload operations. Missions using modern payloads have pushed the limits of on-orbit collection capabilities, but satellite downlinks, constrained by low power transmitters omni-directional antennas, and power/thermally constrained duty cycles are seriously deficient in throughput capability. For low earth orbiting spacecraft, the Signal to Noise Ratio (SNR) changes throughput a pass, primarily due to range, elevation and weather effects, and there are presently no good processes to optimize the data rate for these conditions. Most spacecraft radio frequency (RF) systems are designed to downlink in the worst case, ensuring reliable transmission. This fixes a low, safe data rate that will close a link in: 1) The furthest slant range (highest path loss attenuation), 2) Lowest elevations with respect to the ground station (normally 5 degrees), and 3) 95% worst day for weather (high atmospheric losses). An Adaptive Data Rate Control (ADRC) system is urgently required to provide the best possible downlink rate throughout an entire contract by monitoring SNR, Bit Error Rates (BER), and thereby optimize the downlink rate accordingly. Such systems are frequency band independent and provide the highest possible data rate. The challenges in developing such a system include the real-time evaluation of SNR and BER performance, a synchronized transition of data rate, both on the ground and on the satellite and maintaining the reliability of the data link through a data rate transition.

PHASE I: Maintain compatibility/ continuous liaison with the Center for Research Support (CERES) an Air Force satellite ground control facility; to work within the Space Ground Link Subsystem (SGLS) S-band used by Air Force operational satellites, or alternately, to develop a process designed toward a dedicated antennae a CERES operating up to K-band frequencies; to use data packet acknowledgments to ensure 100% data integrity; and have a bypass configuration to operate as a normal system. 1) Develop architecture, specifications, prototype ADRC system, 2) Develop comprehensive Phase II test plan to conduct real time demonstration with an on-orbit satellite, 3) Provide a simulated contact demonstration of prototype ADRC system.

PHASE II:1) Finalize ADRC system, 2) Provide an on-orbit proof of concept. Install ADRC system at CERES, conduct real-time contacts with an on-orbit satellite. The vehicle and Remote Ground Facility (RGF) control will be conducted remotely from CERES so that the ADRC is transparent to the Air Force Satellite Control Network (AFSCN).

PHASE III DUAL USE APPLICATIONS: The ADRC method is directly applicable to all S-band, Unified S-band, X-band, and K-band transmissions. Programs which are pressed against the upper limit of their systems can use these methods to get more throughput from their current vehicles. Customers include military and commercial satellite systems.

REFERENCES:

1- Ackroyd, Brian. World Satellite Communications and Earth Station Design. Boca Raton, FL: CRC Press, Inc. 1990.

2 - Elbert, Bruce R. The Satellite Communication Applications Handbook, First Edition. Norwood, MA: Artech House Inc. 1997.

3- Freeman, Roger. Radio Systems Design for Telecommunications 1 to 100 GHz, First Edition, New York, NY: John Wiley & Sons. 1987.

4 - Ying Feria, Kar-Ming Cheung, Seamless Data-Rate Changes Using Punctured Convolutional Codes for Time-Varying Signal-To-Noise Ratio, Proceedings IEEE International Conference on Communications ICC í95, 18-22 June 1995, Seattle, WA, IEEE (Cat. No. 95CH35749) Part vol. 1, p. 342-346 vol. 1, 1995.

KEYWORDS: RF Transmission, Data Transmission, Downlink Data Rate, Adaptive Rate Control, Satellite Communication, Space Ground Link Subsystem (SGLS)

AF99-128 TITLE: Evaluation Tool for Satellite Communication Networks Providing Guaranteed Quality of Service

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop a modeling/simulation tool for use in evaluating satellite communication networks that support virtual connections with guaranteed quality of service.

DESCRIPTION: Each virtual connection provided by a terrestrial Asynchronous Transfer Mode (ATM) network provides a guaranteed end-to-end quality of service subject to adherence by a sending user node to specified limitations on the traffic submitted to the network. In terrestrial networks, a user node often is connected to the network by a fixed link, the capacity of which may greatly exceed the cumulative demands of the virtual connections originating from the node. The node is responsible for exercising usage parameter control (UPC) to meet the specified traffic limitations. In networks that include satellite links, link capacity is an expensive resource that must be used as efficiently as possible. Consequently, the capacity from a user node may be negotiated on an as-needed basis. Tailoring the uplink capacity from a node to match the expected traffic acts as an implicit form of UPC. In a network providing virtual circuits with guaranteed quality of service, no specific resources are assigned to a connection. Therefore, the decision whether to admit a new connection is based on a statistical assessment of the consistency of the resulting cumulative traffic from both the new and the existing virtual connections and the quality of service guarantees for those connections. Current call admission control (CAC) algorithms assume explicit UPC implemented by user nodes. The effect of UPC implicit in demand-assigned link capacity has not been addressed. A common military/commercial need exists to develop a modeling/simulation program that addresses this issue.

PHASE I: Define the architecture/specification/preliminary design of a modeling and simulation tool for evaluating CAC algorithms for satellite communication networks that support virtual connections with guaranteed quality of service and tailor uplink capacity to traffic expectations. Provide demonstrations of mutually agreed-upon key elements of this simulation tool.

PHASE II:Code, verify, and test the modeling and simulation tool (Phase I above) utilizing Air Force-supplied data.

PHASE III DUAL USE APPLICATIONS: Interest in supporting network communications over both military and commercial satellites is intense. The ability to define and evaluate CAC algorithms that take account of the special features of satellite links would be considerable interest to all areas of the satellite industry.

REFERENCES:
1- ATM Forum Traffic Management Specification v. 4.0, April 1996, http://www.atmforum.com
2 - "Call Admission Control Schemes: A Review," Perros, H. G., and Elsayad, K. M., IEEE Communications Magazine, November 1996, pp. 82-91

KEYWORDS: Quality of Service, Virtual Connection, Call Admission Control, Usage Parameter Control, Satellite Communications, Asynchronous Transfer Mode (ATM)

AF99-129 TITLE: Reduced-Complexity Receivers for GMSK Modulation

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop and build practical receivers for demodulating GMSK waveforms with BT products on the order of 0.1 to 0.2.

DESCRIPTION: Although the demand for military communications resources is continually on the rise, the availability of usable frequency spectrum is limited. Similarly, with the emergence of a myriad of commercial personal communications services (PCS), highly efficient utilization of available commercial frequency spectrum is paramount. In order to satisfy the growing demand on military communications capability (with a static and possibly shrinking spectral allocation) stringent requirements are placed on the signaling waveforms to be used on future satellite communications systems. Specifically, the waveforms must be bandwidth efficient, as well as power efficient, and must be robust enough to withstand jamming and other types of interference. In addition, it is highly desirable to have the modulator/demodulator as simple to implement as possible. For the commercial service providers, newly available frequency spectrum is obtained at great expense (as evidenced by the recent PCS-band auction, which totaled billions of dollars). The only way for the commercial service providers to recover such staggering initial costs and eventually become profitable is to maximize the capacity of the commercial systems. This again implies the need for bandwidth and power efficient modulation waveforms. One class of waveforms that is known to be highly spectral and power efficient is Gaussian Minimum Shift Keying (GMSK). Theoretical analyses have shown that in order to satisfy military spectral and capacity requirements the bandwidth-time (BT) product of the GMSK waveform must be sufficiently low (<0.2), and the order of the modulation must be 4 or greater. With current state of the art technology, optimum receivers for such waveforms are prohibitively complex to implement. A practical receiver design, of reduced complexity and acceptable performance, although urgently required has not been achieved.

PHASE I: Utilizing Air Force spectral/capacity requirements (above) investigate/identify/develop specific receiver design approaches for evaluation. Develop and validate computer simulation models of selected receiver designs. Based on the simulation results, and with government concurrence, select a final candidate approach and develop a preliminary specification/design. Demonstrate key elements of the selected design.

PHASE II:Finalize selected receiver design. Develop/implement a prototype of the chosen receiver design and demonstrate (mutual Government/ contractor agreed) functionality.

PHASE III DUAL USE APPLICATIONS: Although the military has high potential use for practical GMSK receivers due to stringent waveform requirements as discussed above, and since bandwidth efficiency and power efficiency are among the significant factors that determine profit margin in a commercial system, the practical GMSK receivers developed in Phase I and II will have widespread commercial interest.

REFERENCES:
1- Anderson, et al, Digital Phase Modulation, Plenum Press, 1986.

2 - Murota and K. Hirade, ìGMSK Modulation for Digital Mobile Radio Telephony,î IEEE Trans. Comm., vol. COM-29, pp. 1044-1050, July 1981.
3 - Kaleh, ìSimple coherent receivers for partial response continuous phase modulation," IEEE J. Selected Areas Comm, vol. 7, pp. 1427-1436, Sept. 1989.
4 - Fonseka, ìNoncoherent detection with Viterbi decoding for GMSK signals,î IEEE Proc. Comm, vol. 143, pp. 373-379, Dec. 1996.
5 - Svensson, et al, ìA Class of Reduced-Complexity Viterbi Detectors for Partial Response Continuous Phase Modulation,î IEEE Trans. Comm., vol. COM-32, pp. 1079-1087, Oct. 1984.

KEYWORDS: GMSK, Receiver, Waveform, Modulation, Communications, Spectral Masking, Useable Frequency Spectrum

AF99-130 TITLE: Turbo Code Decoders

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop and build space-qualified decoders for turbo codes of various rates, structures, and complexities.

DESCRIPTION: Channel coding greatly enhances error rate performance and is ubiquitous in modern communication systems. A coded channel requires much less power to achieve a given bit error rate (BER) than an uncoded channel. The cost of this ëcoding gainí is an expansion of the bandwidth required to transmit the information (i.e. the amount of bandwidth expansion, for a given bit error rate, is a function of the code rate). Over the years, many different coding schemes have been investigated by various researchers and several of these codes have become de facto 'industry standards' due to their exceptional coding gain and/or ease of implementation. Successful coding schemes include the families of convolutional codes, Reed-Solomon codes, and 'concatenate' codes consisting of constituent codes form each of the aforementioned families. In general, the concatenated codes provided the highest coding gains and were commonly used in power-limited systems with low BER requirements. In recent times, the military and the commercial sectors have both experienced the intensified utilization of multimedia services, such as electronic mail, video conferencing, and the World Wide Web. As each of these services imposes added demand on system resources, the need for coding schemes with even greater coding gains have become apparent. In recent years, a new class of powerful codes, referred to as 'turbo codes' has been invented. Based on published results, turbo codes could provide greater coding gains than any other known code. Turbo encoders are simple variations/extensions of existing codes; the decoders, however, are more complex and have not yet been successfully field tested. Space qualified turbo decoders, that meet government performance standards, are required in order to realize the gains afforded by turbo codes.

PHASE I: Based on requirements specified by the government, identify specific turbo codes of revaluation. Develop and validate simulation models of encoders and decoders for the selected codes. Develop evaluation tools, if necessary, and measure the performance of the selected codes. Based on the simulation/evaluation results, (and Government concurrence) select specific code(s) for future implementation and produce applicable prototype decoder design(s). Demonstrate key elements of the chosen decoder design(s).

PHASE II:Utilizing specifications and materials meeting government standards, finalize design/develop/build prototype(s) of decoder(s) of the selected code(s) and demonstrate Government/contractor mutually agreed-upon elements of functionality.

PHASE III DUAL USE APPLICATIONS: Turbo codes, having potentially large coding gains, will have widespread applications in any power-limited communications system, military or commercial.

REFERENCES:
1 - C. Berrou, et al, "Near Shannon limit error-correcting coding and decoding: Turbo-codes," Proc. ICC í93, Geneva, Switzerland, pp. 1064-1070, May 1993. (IncludesREFERENCEs to several patents).
2 - S. Benedetto and G. Montorsi, "Design of parallel concatenated convolutional codes," IEEE Trans. Comm., vol. 44, pp. 591-600, May 1996.
3 - G. C. Clark, Jr., and J. B. Cain, Error-Correction Coding for Digital Communications, Plenum Press, 1981.

KEYWORDS: Space, Turbo Codes, Channel Coding, Simulation Models, Error Rate Performance, Turbo Encoders/Decoders

AF99-132 TITLE: High Throughput Terminal/CDMA Modem for Satellite Communications

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Apply code division multiple access (CDMA) digital technology to satellite network communications.

DESCRIPTION: Demonstrate that CDMA technology, used in the wireless communications, can be applied and result in highly cost effective satellite network communications. Theoretically, the CDMA technology used as the modem in the ground terminals, can significantly increase throughput capacity of the majority of current military and commercial satellite networking schemes.

PHASE I:1) Investigate the feasibility of applying CDMA equipment, combined with other commercial off the shelf (COTS) hardware, to satellite networking communications; 2) Simulate the improvement in networking capability; and 3) Design a prototype CDMA-based networking satellite scheme and provide a demonstration of key elements of the design.

PHASE II:1) Finalize the design of Phase I CDMA-based satellite networking scheme; 2) Procure and assemble the hardware to be used as the modem in the ground terminals plus any other required hardware/software; and 3) Demonstrate (with Air Force assistance) the advantages of CDMA-based networking satellite communications scheme.

PHASE III DUAL USE APPLICATIONS: Successful application of CDMA technology to satellite communications could significantly reduce the cost for military and commercial satellite ground terminals.

REFERENCES:

1 - S. Glisic, B. Vucetic, Spread Spectrum CDMA Systems for Wireless Communications, Artech House, 1997
2 - S. Glisic, CDMA Communications, Kluwer Academic Pub, 1995.

KEYWORDS: Digital Compression, Digital Communication, Wireless Communication, Satellite Communication, Code Division Multiple Access (CMDA), Defense Satellite Communication System (DSCS))

AF99-133 TITLE: Universal Data Compression Technology

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop and demonstrate a system with the ability to compress and decompress, in real time, NTSC color video with sound by at least a factor of 1000, with good quality of reproduction.

DESCRIPTION: An important aspect of distributed Command and Control (C2) is the use of video. Video provides interpersonal communications for dispersed personnel, intelligence information from remote sensors, mission planning/execution information, and other functions. Data transfer rates of battlesite communications networks are generally far less than those required to support the transfer of time-critical data. This effort will research and develop a prototype capability which can be used on wired or wireless narrow-band communications channels. The signal processing that is responsible for the data compression/decompression shall be accomplished in real time, with a minimal processing latency. Techniques that address multiple-fidelity resolution depiction shall be addressed and employed in the demo.

PHASE I: Produce/demonstrate a conceptual design of a compression system with a compression ratio of greater than 1000:1 that operates in real time.

PHASE II:The Phase I prototype capability will be refined, extended, implemented in a hardware chip set, and demonstrated over a narrow-band channel.

PHASE III DUAL USE APPLICATIONS: Military C4I, Civilian communications networks, the Internet.

REFERENCES:

1 - Image Compression Through Wavelet Transform Coding, R. A. Devore, B. Jawerth, B. J. Lucier, IEEE Transactions on Information Theory, Vol. 38, No. 2, March 1992.
2 - ISO CD 11172-2 Coding of moving pictures and associated audio-Part 2, Nov 91.
3 - CCITT Recommendation H.261, Video codec for audio-visual services at Px64 Kb/s.
4 - Universal Source Coding for Data Compression, Draft Recommendation for Space System Data Standards, CCSDS 121.0-R1 Red Book, Washington, DC: CCSDS, Nov 95.
5 - A Rational Approach to Testing MPEG-2, J. O. Noah, IEEE Spectrum May 97.

KEYWORDS: Data Compression

AF99-134 TITLE: Generic Intelligent User Interface Agent

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop a Generic Intelligent Interface Agent Architecture and Working Agent

DESCRIPTION: Computer systems are becoming increasingly complex, so complex that the average user is often overwhelmed. The recent research push for intelligent user interfaces attempts to solve the problem by providing complexity abstraction and intelligent assistance [1]. These interfaces can learn individual user preferences and tendencies to provide automated assistance, thereby acting as an "intelligent assistant" which behaves as though collaborating with the user in the work environment and can permit even an untrained user to interact effectively with a complex system [2]. This quickly emerging technology shows great promise and is a national priority.

PHASE I: Investigate the possibility of developing a generic intelligent interface agent architecture and working agent that can operate as part of the USAF Defense Information Architecture (DII) Common Operating Environment (COE). This architecture must be compliant with DII COE requirements and perform complexity abstraction and intelligent assistance for applications residing in the COE.

PHASE II:Develop the architecture and implement a DII COE compliant generic intelligent interface agent that provides complexity abstraction and intelligent assistance to COE applications. The agent must demonstrate clear advantage in user workload reduction and ease of use within an existing COE application when compared to the original application.

PHASE III DUAL USE APPLICATIONS: Intelligent interface capabilities can be used in a wide range of military systems, from agents managing electronic mail arriving at a desktop computer [2] to agents autonomously presenting a fighter pilot with time-critical engagement information in the cockpit [5]. These capabilities can also be used in numerous commercial applications; for example, prioritizing executive corporate correspondence, or workload reduction in the cockpit of a modern commercial airliner.

KEYWORDS: Intellligent Assistant, Complexity Abstraction, Intelligent User Interfaces

AF99-136 TITLE: Intelligent Web Assistant

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop Dynamic and Adaptive Data Mining Techniques for Designing, Developing, and Accessing Large-Scale Data/Knowledge Bases for Intelligent Information Systems

DESCRIPTION: In order for the USAF to fully exploit the Internet and achieve information superiority, it must have web search agents that intelligently mine information from the vast amounts of on-line data. These agents can utilize current natural language capabilities to provide an "Intelligent Web Assistant" that doesn't merely search for keywords, but in fact retrieves and reports information.

PHASE I: Perform preliminary investigation into the incorporation of natural language understanding into a Web search agent that mines and reports information rather than keywords. Investigate the feasibility of integrating multimodal human-computer interaction to include natural language, graphical presentation, and voice recognition. Finally, investigate feasibility of "fire and forget" paradigm of intelligent Web mining to minimize the need for human interaction.

PHASE II:Build an intelligent Web agent that will mine Internet resource and report information, not just keywords, through a multimodal human-computer interface. This search agent will provide multimodal human-computer interaction to include natural language, graphical presentation, and voice recognition. The agent will also be "fire and forget", able to search and compile results with minimal human interaction.

PHASE III DUAL USE APPLICATIONS: An intelligent Web assistant will allow the military to fully exploit Internet resources to achieve information superiority over the Internet's vast resources. Such an agent will be invaluable to users throughout industry and academia.

KEYWORDS: Data Mining, Intelligent Web Assistant, Intelligent Information System, Multimodal Human-Computer Interaction

AF99-137 TITLE: Complex Modeling of Software Components

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Investigate the Ability to Model Complex Software Architectures as a Collection of Components.

DESCRIPTION: Recent improvements in software development techniques have led to the creation of very large scale architectures as a collection of software components. The current constructive simulation community creates unique simulation exercises using a collection of simulations and simulators that interface in a varying number of ways. Many of the components represented in the simulation are funded and developed by different organizations. This has led to a large scale configuration problem that requires costly testing and integration efforts, as well as costly deployments and use. In recent years, modeling techniques have matured enough to be able to represent the specification of software architectures and capture of its collateral information. Applications using these models can support an architecture's testing, integration, deployment, and use. These applications have the potential to greatly reduce the costs involved in these activities, while increasing the overall quality of the architecture's use.

PHASE I: Demonstrate the feasibility of using modeling techniques to represent the complex configurations of the constructive simulation community. Specifically, the modeling techniques and technology investigated should be able to represent semantically rich information about software architectures and their interfaces. The representation should support the composition of applications from the software architectures. In addition, collateral information on the deployment and use of an architecture should be able to be associated with the components represented. The approach investigated should be able to be embedded in applications that end-users in the constructive simulation community can use to support simulations. PHASE I will document an approach for modeling this information and a plan for producing supporting technology.

PHASE II: Implement a tool or technique that can represent the arbitrarily complex configurations of software architectures. While the tool or technique should be general enough to apply to any software architecture, the particular area of interest is the constructive simulations community. PHASE 11 should demonstrate the technology by building a model ofthe software used during constructive simulations, and several applications that use the model to support constructive simulations exercises.

PHASE III DUAL USE APPLICATIONS: This approach and possible application have applicability to both the government and commercial marketplace. Large-scale architectures are being constructed in industry, particularly in the financial and telecommunications market, that are requiring greater need for automated configuration support. In addition, government procurements for large-scale object-oriented systems will produce architectures premised on composable components to create unique applications. These applications require sophisticated composition techniques and technology similar to results expected in PHASE II.

KEYWORDS: Modeling, Simulation, Automated Synthesis, Model Based Synthesis, Software Architecture, Inter-Linked Knowledge, Constructive Simulation, Knowledge Based Software

AF99-138 TITLE: VHDL Based ULSI to VLSI Design Partitioning Tool

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Enable the implementation of ULSI ASIC system functionality through innovative design partitioning technology at the VHDL level.

DESCRIPTION: Present synthesis tools are oriented to single die implementations. For many reasons, the designer needs the capability to automatically partition the design at arbitrary levels of abstraction (behavioral, presynthesis RTL, and post Synthesis RTL), and across multiple devices based on user specified constraints. Gate densities for future DoD system ASICs (Application Specific Integrated Circuits) will be greater than one million gates. Scaleable, automated, and interactive design synthesis and partitioning tools are desired that would allow the optimized generation of ULSI (Ultra Large Scale Integration) VHDL (IEEE 1076) (Very High Speed Integrated Circuit Hardware Description Language) designs into several smaller VLSI gate designs integrated onto a common Multi-Chip Module (MCM). These tools must be designed to: 1) facilitate the optimized design partitioning process, 2) aid in chip level I/O placement and drive selection, 3) allow for the modeling and back annotation of MCM interconnect delays and load for timing simulation into the VHDL models, 4) maintain desired performance, 5) automatically insert the appropriate IEEE 1149.x test structures for each component and MCM, 6) automatic generation of VHDL test benches and WAVES (IEEE 1029.1) test vectors for each component, and MCM, and 7) easy targeting to arbitrary cell libraries and semiconductor processes, including Radiation Hardened processes. The result of this effort will be a general software tool capable synthesizing > 1M gate VHDL designs and partitioning the design into an arbitrary number of die based on user specified constraints.

PHASE I: Activity shall include (but not be limited to): 1) a specific functional definition of the ULSI to VLSI synthesis and partitioning tool, 2) identification of appropriate user interfaces and symbolic representations, 3) a comprehensive overall preliminary system design, 4) demonstration of ULSI to VLSI synthesis/partitioning tool integration with existing Electronic Design Automation (EDA) ASIC design flow, and 5) an Air Force/contractor agreed upon preliminary demonstration of system building blocks.

PHASE II:Activity shall include (but not be limited to): 1) Completion of the ULSI to VLSI synthesis/partitioning tool software system, 2) full scale demonstration of the system on a 1M+ gate design (design provided by Air Force), 3) targeting to an Air Force Specified MCM process and using at least one radiation hardened parts suppliers' ASIC library, and 4) a simulated comparative performance analysis of the unpartitioned design to the multi-component partitioned design in accordance with the above (Description Section) requirements.

PHASE III DUAL USE APPLICATIONS: Successful development of a scaleable, automated, interactive design synthesis/partitioning tool will be in demand by both commercial and DoD microelectronics communities. A number of DoD uses will come from space system developers because radiation-hard processes are typically lower density than standard processes. A significant commercial use of this technology is expected to be in the commercial space telephony, communications, and resource imaging sectors. Additionally, it is applicable to both military and commercial products where high performance, tightly coupled ASICs on common MCM substrates are utilized because their circuitry is too large to fit onto a single silicon die; such as many digital signal processing applications, real time medical imaging, logic emulation, high speed computing, dedicated parallel processors, and resource constrained devices such as Gate Arrays, FPGA's, PLD's etc.

REFERENCES:
1. Charles A. Harper, Editor: Electronic Packaging and Interconnection Handbook, McGraw-Hill Inc., ISBN 0-07-026684-0, TK7870.15.E42, 1991
2. S. Raman, L.M. Patnaik, Performance Driven MCM Partitioning Through an Adaptive Genetic Algorithm, Proceedings of the 8th Annual IEEE International ASIC Conference and Exhibit, pp. 143-146, 1995.
3. M. Shih, E.S. Kuh, R.S. Tsay, Performance Driven System Partitioning on Multi-Chip Modules, Proceedings of the 29th ACM/IEEE Design Automation Conference, pp. 53-55, 1992.
4. K. Roy, C. Sechen, Timing Driven Partitioning System for Multiple FPGAs, VLSI Design, Vol. 4, No. 4, pp. 309-328, 1996.

KEYWORDS: VLSI, VHDL, IC Layout, Microelectronics, Multi-Chip Modules, Design Partitioning

AF99-139 TITLE: VHDL Text-to-Graphics Translation and Text/Graphics Co-Simulation

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop products to support the design, modeling, and simulation of complex digital microelectronic systems and to enable re-use of existing models.

DESCRIPTION: Very High Speed Integrated Circuits (VHSIC) Hardware Description Language (VHDL) is an IEEE standard language for definition, simulation, and synthesis of digital systems. Several graphical and symbolic tools are available for capturing VHDL textual descriptions, but there is not a complete set of VHDL text-to-graphics and graphics-to-text tools. Schematics, block diagrams, data-flow graphs, state diagrams, structural hierarchy maps, flow charts, data dependency graphs, etc. can be extremely valuable in understanding models and finding problems in models. Such capability would lower the cost of creating new models and support reuse of existing models. Designs captured graphically should be intermingled with text generated designs. This is because a given design or portion of a design will lend itself more to one modeling technique or representation than to another depending upon the nature of its functionality. The designer should be given the freedom to choose and efficiently utilize the representation most natural to the problem. VHDL source should automatically be generated from the graphical representations and graphical representations generated from text. They may be freely interspersed in any order. Simulation should be automatic from any representation or mix. Test benches should be automatically generated for graphical representations. Captured test vectors should be converted from graphics-to-text. The test vector text format should be the Waveform and Vector Exchange Standard (WAVES - IEEE 1029.1). This topic solicits research and development in VHDL text-to-graphics and graphics-to-text tools. Additionally or alternatively this topic solicits research and development in co-simulation of multiple logic modeling representations.

PHASE I:The preliminary design of the tool will be performed. The functionality, user interface, and design environment interface will be completely specified.

PHASE II:The tool will be constructed, evaluated, and demonstrated. REFERENCE manuals and user guides will be developed.

PHASE III DUAL USE APPLICATIONS: The design automation tool will be readied for market and tested by potential electronic design customers in the military and commercial design communities. Production, marketing, and support plans will be developed. All tools developed under this topic will be inherently dual-use. This is because the same methods used to design electronics for military systems are applicable to commercial systems.

KEYWORDS: Graphical Design, Microelectronics, Software Computing, Modeling and Simulation, Integrated Circuit Design, VHSIC Hardware Description Language (VHDL), Application Specific Integrated Circuit (ASIC)

AF99-140 TITLE: Immersive Wargaming

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop an immersive wargaming environment in which users could "experience" past or present military conflicts.

DESCRIPTION: This effort involves a marriage of the enabling technologies of virtual reality, modeling and simulation, game theory, human-computer interfaces and distance learning. In an immersive wargame, a (virtual) battlefield commander would be capable of viewing all aspects of an on-going conflict within a realistic synthetic environment, using a multi-sensory interface system. This effort would result in a hybrid software/hardware synthetic environment in which a user (player) could be fully 'immersed' into a synthetic (initially, modern battlefield) environment. Central to this development is the extensive leveraging of practices and tools arising from recent advances in Distributed Interactive Simulation (DIS) and the emerging High Level Architecture (HLA) protocol. Ultimately, this activity would culminate in a valuable 'edutainment' tool, whereby would-be decision-makers could play armchair general within any of a library of historical conflicts which would be played out (simulated) against other live players, or a doctrinal rule set. Technology can also be used for small unit tactics practice/team play for soldiers/pilots through company/squadron commanders and higher level command functions. This would also allow units to practice in territory that does not provide the "known solutions" of current unit practice areas (e.g., Fort Irwin, Red Flag, etc.). It promotes team-building and unit cohesion, promotes research into the concept of "dynamic campaign assessment" and otherwise allows for realistic simulation of the "fog of war." This effort would be structured into three logical phases, as follows:

PHASE I: Develop an advanced DIS/HLA tool and protocol, along with virtual reality concept and equipment, to effect a maintainable, repeatable present-day military conflict, such that it could be used to immersively train potential decision-makers. Current COTS software (Marathon, DamageInc., etc.) might be used as a starting point for user interface software.

PHASE II: Extend the conflict domain to include past conflicts (e.g. Grenada, Falkland Islands, Desert Storm, Battle of Oriskany, Battle of Shiloh Church, etc.) in a plug-compatible conflict/scenario library.

PHASE III DUAL USE APPLICATIONS: The ultimate market is the burgeoning edutainment market; from teens interested in testing their mettle against the Pattons or Grants of the past to philosophical historians (e.g., what would have happened if Eugene McCarthy had won the presidential election?).

KEYWORDS: Wargaming, Simulation, Synthetic Environments, Modeling and Simulation, High Level Architecture

AF99-141 TITLE: Defensive Information Operations Planning Tool

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop an knowledge-based tool to predict information system vulnerabilities, identify threats, and model/simulate attack results on these systems.

DESCRIPTION: Current Vulnerability Assessment and Risk Management methodologies are static and do not operate in real-time on dynamically changing information systems architectures. The vulnerability assessment is performed, the vulnerabilities are identified and recommended countermeasures are provided. From here it is up to the operator to install the countermeasures based on some cost benefit analysis or assume the risk. These assessments are performed on a periodic basis and do not account for the dynamic Information System changes that occur daily or in a mobile warfare scenario. Additionally, these assessments are performed after the information system is deployed; in many cases this is too late and vulnerabilities are already being exploited before the assessment has been performed, leaving the enemy holes to install future attack backdoors into the Information system. A planning tool is required that allows for the modeling of the planned deployed Information system architecture. From this model, blue force information system vulnerabilities can be explained relative to their significance to performing mission critical tasks, countermeasures can be applied and their success tested by simulating Information attacks. This model can then be used for the deployed Information system architecture and once deployed, dynamic changes in the architecture can be detected by continuous monitoring. These changes will trigger the planning tool to effect a change in the model and the reassessment and generation of new Course of Action (COA) options for the deployed architecture.

PHASE I: Develop a plan for creating automated/semi-automated knowledge-based tools capable of assessing information system vulnerabilities, identifying threats, and performing modeling/simulations of attack results on these information systems.

PHASE II:Create automated tools which will afford an operator the opportunity to assess vulnerabilities and risks, investigate a number of countermeasures to notional attacks for defense optimization, and provide Course of Action (COA) options for real-time reaction in a dynamically changing warfare scenario. Demonstrate a prototype knowledge-based defensive information planning tool on an Air Force scenario.

PHASE III DUAL USE APPLICATIONS: Security of information is extremely important to corporations, banking, and financial institutions, the automated tools developed under this effort can be applied to assist them in assessing their information vulnerabilities and developing courses of action to minimize the threats they face.

KEYWORDS: Risk Assessment, Modeling and Simulation, Knowledge Based Planning, Information Vulnerabilities, Defensive Information Operation, Automated Course of Action (COA)

AF99-142 TITLE: Media and Medium Control for Optimized Internetworking

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop system for intelligent optimization and internetworking for software radio pre-planned product improvement (P3I)

DESCRIPTION: Considering the soon-to-be-developed Software Defined, Digital, Reprogrammable Radio for the services (Joint Tactical Radio System, or JTRS), we need to be planning for the next generation of improvements to a JTRS, given the starting point of a fully (RF through I/O) modular, open, scalable and re-programmable system [with spare processing and memory (storage) capacities]. With a software radio which can be controlled and optimized with resident system software, what adaptive and intelligent control can be developed to enhance networking and quality/speed of service? Intelligent manipulation or adaptation of at least five functions can enhance the military radios of the future, and improve the digitized battlefield information flow.

PHASE I: Routing and switching, multiplexing and de-multiplexing, dynamic packet-control (size, structure, etc.), prioritization and preemption of service, adaptive control of media and/or channel-selection all need to be investigated as a system for intelligent optimization and internetworking. Intelligent optimization also includes: metric gathering, analysis, assignment and apportionment, monitoring and tracking of system resources. Study and analyze what software radios will need (resources, information, algorithms, etc.) to employ these control features. Develop model to determine which will provide the best pay-back in cost-effectiveness, and capability. Initial focus should be on network implications of such optimization.

PHASE II:Design, develop, and demonstrate in a laboratory environment the capabilities identified as most promising in Phase I.

PHASE III DUAL USE APPLICATIONS: Intelligent optimization of resources is useful for commercial as well as military applications. Any user (Civil, Military, or Commercial) who requires optimization for quality or speed of service will need such technology.

REFERENCES: Operational Requirements Document (ORD) for Joint Tactical Radio (JTRS), 11/14/97

KEYWORDS: Digitized Battlefield, Routing and Switching, Dynamic Packet Control, Quality and Speed of Service, Multiplexing and De-Multiplexing, Prioritization and Preemption of Service, Modular/Open/Scalable/Reprogrammable Systems, Software Defined Digital Reprogrammable Radio

AF99-143 TITLE: DII COE Component Framework

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Rapid application development/deployment within DII COE using component-based technologies.

DESCRIPTION: Distributed component applications are the next revolution in software development. A growing number of DOD and industry efforts are beginning to prove this technologyís promise of widespread software reuse, low-cost platform requirements, and rapid design-to-field cycle time. The reusable nature of components is the backbone behind their innovation. The commitment of companies such as Microsoft, Sun Microsystems, and IBM, to deliver end-to-end solutions for building and operating distributed component applications is enormous. If each solution were based on a single component standard, the specification for implementing and invoking a componentís functions, a component developer could use a mixture of cross-vendor products to build and execute the application. However, because the stakes are so high in becoming the defacto standard, the market has divided into three competing technologies for distributed component applications ñ Distributed Component Object Model (DCOM), Common Object Request Broker Architecture (CORBA), and Java. While each group is rapidly advancing their component-based product line, application developers are left with the decision of which technology to embrace. The creation of a component framework, which transcends the competing component standards, will enable application developers to assemble applications from components written by any vendor, in any language, using any interface standard, for their particular infrastructure. This would maximize the chief contribution of component-based development ñ leveraging other developerís efforts to construct powerful, inexpensive, and robust applications in record time frames. A developer focused on a Windows NT environment, geared to support DCOM, could still use components created by another developer who focused on a Unix environment supporting CORBA. The commitment of the Defense Information Infrastructure (DII) Common Operating Environment (COE) community to Windows NT and Unix platforms makes DII COE an obvious target for a component framework specification. This effort will prototype and evolve a component framework for DII COE application developers as it builds a DII COE-compliant distributed component application using both DCOM and CORBA based components and demonstrates its operation on a DCOM, CORBA, and Java distributed component platform (DCP).

PHASE I:Develop and demonstrate a DII COE-compliant distributed component application, using DCOM, CORBA, and Java based components. Propose a prototype component framework which aides in the construction of this application for each DCP.

PHASE II:Develop and demonstrate distributed component applications for the DCOM, CORBA, and Java DCPs using the prototype component framework. Identify proposed framework improvements for DII COE application developers.

PHASE III DUAL USE APPLICATIONS: Develop and implement a business plan for marketing the component framework to DII COE application developers and upgrading the framework to support developers for other infrastructure environments. Component frameworks are widely regarded as the missing link in realizing the tremendous potential of distributed component applications. A framework developed for the DII COE community will be extensible to the entire software engineering community at large.

REFERENCES:

1. Published by: John Wiley & Sons, Inc., 1998 -- Title: COM and DCOM; Microsoftís Vision for Distributed Objects, Roger Sessions

2. Published by: IEEE, Computer , March 1998 -- Title: The Emergence of Distributed Component Platforms, David Krieger and Richard M. Adler

KEYWORDS: Java Components, Hardware Clustering, Component Frameworks, Multi-Tiered Architectures, Distributed Component Applications, Distributed Component Object Model (DCOM), Common Object Request Broker Architeecture (CORBA), Defense Information Infrastructure Common Operating Environment

AF99-144 TITLE: Rapid Prototyping Environment for Information System Design and Acquisition

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Build a distributed simulation environment to assure mission-specific system performance and develop system-level databases

DESCRIPTION: This program will build, document, and validate a generic distributed modeling and simulation environment which can be used by product development teams to rapidly quantify the performance of a proposed design against a documented set of operational requirements in a specified scenario. This environment will make maximum use of the results of the DARPA-sponsored Simulation Based Acquisition program and use the AFRL Collaborative Engineering Environment as its backbone. The environment will accommodate multiple engineering disciplines (e.g., mechanical, electromagnetic, thermal) and takes into account the mutual effects of the physics associated with the respective engineering disciplines. The environment will provide for the collection, storage, distribution, and configuration control of all data associated with a system and its various subsystems, equipment's, and components. This system-level database will be available for future enhancements, upgrades, and replacements of any unit within the system.

PHASE I:The initial environment will contain a suite of electromagnetics, mechanical, and thermal simulation programs suitable for use in antenna design, assessing its performance in the presence of the surrounding structure. Collaboration and distributive processing via the Collaborative Engineering Environment and using the tools and processes developed under the Simulation Based Acquisition project will be demonstrated. An initial schema for the product model at the engineering level will be developed and demonstrated.

PHASE II:Extend the original engineering set to include other disciplines (e.g., flight dynamics), and develop suites of tools for other products or applications (e.g., education, MEMS), developing and extending product models as necessary. Develop software utilities to assist in the interface/insertion and maintenance of analysis tools within the environment, and tools for the development and use of the schema for the product model.

PHASE III DUAL USE APPLICATIONS: Military applications include command and control, communications, intelligence, surveillance, and reconnaissance. Civilian applications include commercial transportation, public safety, and wireless communications. The framework and optional suites of tools would reduce the cost and increase the effectiveness of engineering education. Rapid prototyping would enable a quicker transition from basic research to products which increase the quality of life, minimize the risk of mass marketing a defective product, and reduce the cost to market while increasing the quality of the product.

KEYWORDS: Aircraft Modeling, Virtual Prototyping, Digital System Models, Concurrent Engineering, Modeling and Simulation, Collaborative Engineering, Distributed Interactive Simulation

AF99-145 TITLE: Low Temperature Compression Set Resistant O-ring Material

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop low temperature and compression set resistant elastomeric materials for use in constructing aircraft fuel and hydraulic seals.

DESCRIPTION: Current materials used to construct aircraft hydraulic and fuel seals are required to seal at -650F or -400F depending on the aircraft system. Current materials, such as nitrile and fluorosilicone, that can seal at such temperatures are very prone to compression set. In a relatively short period of time the seals lose their elasticity and, consequently, their ability to seal.

The current fuel system seals are required to be resistant to all types of aircraft jet fuels, including JP-4, JP-5, JP-8 and Jet A. They are required to operate at temperatures between -650F and 1600F at low pressures. Recent advances in aircraft thermal management have increased the return temperatures of the fuel to 2250F. Therefore, new materials should be capable of sealing from -650F to 2500F. Since the Air Force converted to JP-8 fuel, there has been a debate to raise the low temperature to -400F. This is because JP-8 has a slush temperature of about -500F. Proposals for a good compression set resistant material that has a -400F to 2500F operating range will be considered.

Current aircraft hydraulic systems normally operate in the -650F to 2750F temperature range at pressures of 3000 to 4000 psi. The weakness of the elastomeric materials requires the use of plastic back-up rings to prevent extrusion of the seals at high pressures. The low temperature requirement in some systems is -400F and other current systems that require -650F may relax the temperature requirement to
-400F. Therefore, proposals for compression set resistant materials that can achieve a -400F to 2750F will be considered.

Nitrile seals are heavily plasticized in order to obtain the low temperature capability; however, this also makes the material very weak especially in the area of compression set. Both hydraulic seal and fuel seal formulations are effected by this. However, there are some recent developments with hydrogenated nitrile materials that may make it possible to develop a low temperature compression set resistant material. Fluorosilicone seals that are used in fuel systems are also very compression set prone due to the inherent weakness of the material backbone. Fluorocarbon materials have not been able to achieve the low temperature requirements. Even the low temperature formulations do not obtain a -400F sealability. This material is very good in every other way and would be the material of choice if the low temperature requirements could be met without giving up on any of the other properties.

PHASE I: Define, determine feasibility, and show proof of concept for preliminary low temperature and compression set resistant hydraulic and fuel seal materials. Select and evaluate promising formulations of candidate materials. These materials shall be applicable for substitutes for MIL-P-5315, MIL-R-25988, and MIL-P-83461 seal materials.

PHASE II:Further develop, optimize, and scale up candidate material(s) from bench scale to arger quantities for extensive physical properties testing. Test materials in static and dynamic seals test fixtures. Develop and execute a technology transition plan for the best materials to commercial application.

PHASE III DUAL USE APPLICATIONS: The materials and technology developed under this program would have numerous dual use applications. The most obvious is for commercial fuel seals. Technology may also be applicable off-road vehicle seals.

KEYWORDS: Low temperature, Aircraft fuel seals, Aircraft hydraulic seals

AF99-146 TITLE: Development of Static Dissipative Hard Laminate Surfaces

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Develop a cost effective product that will pass MIL-PRF-87893B performance specifications for a Type I Rigid Worksurface.

DESCRIPTION: Electrostatic charge dissipation on worksurfaces has been well documented to prevent considerable damage to electronic components during their handling. Charge dissipation has been successfully implemented in the softer, more pliable worksurfaces (Type II and Type III of MIL-PRF-87893B). These materials are made from polyvinyl and rubber doped with conductive ingredients. Although the current hard laminates (Type I) possess acceptable resistance values in the range of 1 x 106 to 1 x 109 ohms, they do not dissipate charge from items placed upon them. This is most likely due to high contact resistance between the aluminum disk and the worksurface. The complete test methods for evaluating charge dissipation and other electrical properties of all three types of worksurfaces are described in MIL-PRF-87893B. Most of the current hard laminates for counter tops are made from thermoses melamine resin impregnated into paper products and formed under high pressure and heat. A variety of electrically conductive components (fibers, ions, salts, etc.) have been added into a subsurface portion of the laminate to promote charge dissipation. The surface resistance of the very topmost layer may be a key to passing the Charge Dissipation Test. Conductive organic polymers which are compatible with melamine resin may reduce the surface resistance. Hard laminate surfaces are preferred over softer surfaces for their durability (i.e., cut, puncture, and abrasion resistance) cleanability and writing surface. Humidity is known to affect the ability of a surface to dissipate electric charge. A surface is more likely to fail to dissipate a charge at 10% rather than 50% relative humidity. Air Force electronics are particularly vulnerable to electrostatic discharge (ESD) because they are often exposed to very dry or very cold conditions that promote static discharge.

PHASE I: Identify materials that effectively overcome the surface phenomena mentioned above and additionally meet all performance requirements of MIL-PRF-87893B in a cost effective manner. This means that the present industrial process should be changed as little as possible to implement the solution. Evaluate the compatibility of these materials with melamine thermosetting resins and the process commonly practiced in hard laminate production. Perform preliminary testing of the materials in accordance with MIL-PRF-87893B.

PHASE II: Thermoanalytical, thermomechanical and theological characterization shall also be generated on the candidates which look most promising and compared to materials currently used.
Prepare small-scale laminates (23 x 23 inches) using technology developed in Phase I and having the thickness specified for Type I materials in MIL-PRF-87893B. These will be tested according to MIL-PRF-87893B. The Air Force will participate in the testing effort.

PHASE III DUAL USE APPLICATIONS: Several large companies in the business of producing counter tops could benefit from new technology derived from this effort. The Air Force in particular and the electronics industry as a whole would benefit from hard laminate worksurfaces that truly remove the charge on items placed upon them.

REFERENCES: MIL-PRF-87893B. US Patents: 4784908, 5244721, 5275876 (Nevamar); 4540624 (Westinghouse); 4454199, 4455350, 45899S4, 4645717, (Charleswater); 4891264 (Chisso); 4472474 (Formica).

KEYWORDS: Static dissipative worksurface, Static dissipative laminate, Melamine hard laminate, Conductive polymer & melamine.

AF99-147 TITLE: Removal of Oxide Films from Nickel Based Superalloy Fracture Surfaces

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop an inhibited chemical etchant to remove oxide films from nickel based superalloy fracture surfaces.

DESCRIPTION: Failure of nickel superalloy gas turbine engine components during operation leads to the formation of oxide films on the unprotected fracture surfaces. Failure analysis of these components is made difficult, if not impossible, in many cases by the masking nature of these layers. Current fracture surface cleaning techniques (acetate film replication and plasma etching) prove themselves inadequate at removal of the oxide films and preservation of the fracture surface, respectively. Inhibited chemical etchants to remove oxide films from steels have been developed to preserve the base metal during pickling in the manufacturing processes. No similar process is required during nickel superalloy production and, therefore, no such inhibitor has been developed.

PHASE I:Advance research into the development of an inhibited chemical etchant for the IN-100 nickel superalloy system. Perform an analysis of the chemical reactions required to remove the oxide films that form when exposed to high temperature combustion gases while being inhibited from attacking the IN-100 basic composition. Develop inhibited etchant(s) that may reproduce these reactions. Develop a test methodology and matrix for the testing of the developed etchant on IN-100 as well as other selected nickel based superalloys. Document all work in a report format.

PHASE II:Produce and document fracture surfaces (tensile, fatigue and stress rupture) per the Phase I test matrix. Expose fractures to a gas turbine type environment to produce oxide films of varying degrees. Attempt to remove films by acetate film replication. Document results. Remove oxide films using developed etchant(s) per matrixed test procedures. Document results and compare to clean fracture.

PHASE III DUAL USE APPLICATIONS: A successful inhibited chemical etchant would benefit the entire aerospace engine industry by allowing improved failure analysis of governmental and commercial gas turbine and rocket components. Such an inhibited etchant may also find application as a nondestructive cleaning agent.

REFERENCES:

1. Kofstad, P., "High Temperature Oxidation of Metals", Wiley, New York, 1996.
2. Hauffe, O., "Oxidation of Metals and Alloys", Plenum Press , New York, 1965.
3. Kubascheuski O. and Hopkins, B.E., "Oxidation of Metals and Alloys", Butterworths, London, 1962.
4. Ignation D.V. and Shamgundja, R.D., "Mechanism of the Oxidation of Nickel-Chromium Alloys", Moscow, 1960.
5. Wasielewski, G.E., "Nickel-Based Superalloy Oxidation", AFRL-TR-67-30, January 1967.

KEYWORDS: Nickel, Fracture Cleaning

AF99-148 TITLE: High Temperature Structural Materials for Advanced Space, Missile, and Aircraft Systems

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop and characterize advanced high temperature structural materials.

DESCRIPTION: Advanced high temperature structural materials are required to meet the performance objectives of future Air Force space, missile, and aircraft systems. For example, these materials are critical to doubling the propulsion capability of rocket engines and gas turbine engines, and for extending the range of uninhabited air vehicles. Their application will enable the attainment of Air Force goals for global reach and global power. New approaches are requested to develop and characterize (a) advanced high temperature structural ceramic composites (1800|F to 3500|F, excluding carbon-carbon composites), (b) intermetallic materials and composites (1800|F to 3000|F, excluding nickel aluminides) and (c) model forming processes for advanced structural materials. For ceramic composites, research is focused largely on continuous fiber reinforced ceramic matrix systems and may include the following: (a) new, unique ceramic composite development; (b) novel matrices suitable for continuous fiber reinforcement (applicability to composites must be demonstrated), (c) fiber/matrix interface treatments engineered for toughened behavior and stability; (d) continuous ceramic fiber development; (e) interpenetrating multiphase oxide structures where the mechanical properties are limited by the interphase spacing, not the grain boundaries (f) test techniques to determine mechanical and physical behavior (such as failure modes, crack and void growth, oxidation, stress-strain, cyclic stress-strain, etc.) as a function of temperature and loading history; and (g) analytical modeling of composite behavior. For intermetallic materials, research is limited to: (a) methods for modeling intermetallics which lend insight into chemistry selection and control, as well as microstructural selection and control; and (b) methods of synthesizing bulk quantities of intermetallics to provide chemistry and microstructural control on a submicron scale while maintaining the ability to vary and control the final microstructural scale. For modeling of forming processes, research may include modeling of (a) the unit forming process; (b) the material behavior in response to the demands of the unit process; (c) the interface between the work piece and the die or mold; and (d) novel methods for obtaining physical property data and constitutive equations for insertion in models. Modeling effort may be directed at rapid prototyping and/or solid freeform fabrication for the above materials.

PHASE I: This program will focus on the critical issues which when successfully addressed, will provide proof of concept. Proposal should demonstrate reasonable expectation that proof of principle can be attained within Phase I.

PHASE II:This program will be structured to develop and refine those feasible concepts to the point where performance is demonstrated on a scale sufficient to permit an assessment of the ultimate application potential to help meet Air Force advanced materials needs.

PHASE III DUAL USE APPLICATIONS: The developed approaches would have broad commercial applicability due to the large number of commercial air, space, and engine systems that have materials requirements of a very similar nature to those faced by the DoD. These materials are critical to affordable access to space for both the military and commercial sectors, where their use in light weight, high temperature, durable propulsion and thermal protection systems is critical. Various energy conservation applications, e.g., radiant burners, heat exchangers, power turbines, and hot gas filters are also pertinent. For the turbine applications in particular, these materials permit more efficient and clean operation, saving precious natural resources while limiting pollutant emissions.

REFERENCES:
1. "Ceramic Engineering & Science Proceedings: 21st Annual Conference on Composites, Advanced Ceramics, Materials, and Structure," 18[3-4], The American Ceramic Society (1997).
2. R. J. Kerans and T.A. Parthasarathy, "Theoretical Analysis of the Fiber Pullout and Pushout Test," J. Am. Ceram. Soc., 74 [7] 1585-96 (1991).
3. A.G. Evans and D.B. Marshall, "The Mechanical Behavior of Ceramic Matrix Composites," Acta Metall., 37 [10] 2567-83 (1989).
4. D.M. Dimiduk, M.G. Mendiratta, and P.R. Subramanian; "Development Approaches for Advanced Intermetallics Materials - Historical Perspective and Selected Successes," in Structural Intermetallics, R. Darolia, J.J. Lewandonski, C.T. Liu, P.L. Martin, D.B. Miracle, M.V. Nathol eds., The Minerals, Metals, and Materials Society (TMS), Warrendale, PA (1993) p. 619-630.

KEYWORDS: Fibers, Ceramics, Interfaces, Composites, Intermetallics, Process Modeling, Characterization, Environmental Protection

AF99-150 TITLE: Lightweight Metallic and Metallic Composite Materials for Aircraft and Space

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop innovative approaches for improving the performance, durability, and cost-effectiveness of lightweight metallic and metallic composite materials.

DESCRIPTION: Metals based on aluminum, titanium, and their alloys and composites are key structural materials used in the construction of current vehicles and propulsion systems for air and space. The selection of which particular material to use for any given component involves a consideration of (1) that material's expected mechanical and environmental performance under the specific conditions involved and its resultant durability, (2) any effects of that material choice on system weight and center of gravity, and (3) the cost of producing the material, manufacturing the component, and the costs to maintain, repair and replace the component. While the specific levels of these requirements and the optimum balance between them varies between specific applications, the requirement to do more and cost less with structural materials is pervasive. This translates to a continuous need to improve the fundamental understanding of these materials, a continuous innovation in the microstructural approaches used for their development, and continuous creativity in the processing used to manufacture raw materials, as well as components. For lightweight metals, novel approaches for alloy development, heat treatment, processing, and characterization of conventional and advanced structural metals/MMCs are sought which might result in improved material performance and durability, reduced weight, and/or reduced cost for specific vehicle structure or engine applications. For example, in the area of discontinuously reinforced metals, new approaches might be proposed to develop improved materials, production methods, prediction tools, and fabrication schemes for aerospace structural and electronic packaging applications which: a) significantly reduce the cost of producing/maintaining a flight-worthy finished component; b) increase key materials properties such as fracture toughness, strength, stiffness, fatigue life, creep, and high temperature stability; or c) enhance predictive capabilities for composite materials properties and processing in ways which widen the scope of their application.

PHASE I: The end product of a Phase I program would be the establishment of the technical feasibility for the proposed approach. Initial economic feasibility would also be required, if applicable. All of the critical material issues involved with the selected approach will have been addressed.

PHASE II:The technology developed in Phase I would be refined, matured, and possibly scaled up, in Phase II. The ability of the technology to meet Air Force needs would be demonstrated.

PHASE III DUAL USE APPLICATIONS: As the structural metals and metallic composites used in both military and commercial aircraft/spacecraft are similar, it is anticipated that there would be broad applicability for the technology developed here.

REFERENCES:

1. "Titanium Castings: From Turbine Engine to Airframe," Modern Metals, vol. 51, n. 4, 1 May 95, p. 58R.
2. E. A. Starke, Jr. and J. T. Staley. "Application of Modern Aluminum Alloys to Aircraft," Progress in Aerospace Sciences, vol. 32, n. 2/3, 1996 p. 131.
3. "Spray Forming Could Cut Component Cost," Aviation Week and Space Technology, vol. 146, n. 11, 17 Mar 1997, p. 102.
4. "Aluminum Composite Doubles Lifetime of F-16 Ventral Fin" Advanced Materials & Processes, ASM International, Oct. 96 p.7.
5. "Wright Laboratory Success Stories, A Review of 1996," Wright Laboratory, WPAFB, OH 1997, pp. 56, 151. WL-TR-97-6002, ADA 323 748.

KEYWORDS: Cost, Titanium, Aircraft, Aluminum, Magnesium, Durability, Processing, Composites, Performance, Sustainment, Space vehicles, Heat Treatment, Turbine engines, Process Modeling, Characterization, Alloy Development, Structural Metals, Metal Matrix Composites, Discontinuously Reinforced Metals

AF99-152 TITLE: Laser Radar Techniques for Multi-Station Vibration Monitoring

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Investigate the use of laser radar techniques and fiber optics for monitoring machine tool vibrations at multiple locations.

DESCRIPTION: Machine tool vibration related problems encompass poor surface finish, reduced dimensional accuracy, increased cutting tool wear and fracture, and even damage to the machine tool itself. Chatter, the most limiting form of vibration, also causes noise levels that exceed acceptable limits. There is the potential to encounter chatter in any machining operation. Present day production machine tools are designed to control vibrations by optimizing the mass and stiffness characteristics of the structure, and/or by adjusting process throughput. Process planners, parts programmers, production floor managers and operators all tend to select conservative metal removal rates (i.e., feedrates, speeds, depth) which, in turn, reduce machine tools' overall productivity. With today's requirements for higher speeds, lighter weights, smaller tolerances, and greater process flexibility and efficiency, traditional approaches make precision requirements to an accuracy of less than one ten thousandth of an inch. The combination of laser radar techniques coupled with fiber optics would allow a rugged and compact system to be assembled to measure, in real-time, the amplitude of vibration in the machining process. Furthermore, the use of fiber optics makes it possible to measure vibrations at multiple stations or locations with one compact system.

PHASE I: Will investigate using laser radar and fiber optics as a viable approach to monitoring vibrations at multiple locations. The goal of this Phase I effort will be a proof of concept system demonstrating the capability of accurately measuring vibration.

PHASE II: Will build upon the Phase I work to a) design a robust, reliable and maintainable prototype system, b) fabricate the prototype system, and c) validate the prototype system by measuring vibration at a minimum of five machine tool stations nearly simultaneously. The prototype system will be capable of being integrated into an existing machine tool environment.

PHASE III DUAL USE APPLICATIONS: The results of this program will provide vibration measurement and machine tool control for both Government and commercial applications. Other potential applications are aircraft vibration measurement, precision coordinate measurement, rapid prototyping and structural vibration analysis.

REFERENCE:. "Laser Vibration Sensing," Kachelmyer, Alan L. and Schultz, Kenneth I. Journal Info: The Lincoln Laboratory Journal, Sprg 1995 v 8 n 1.

KEYWORDS: Laser radar, Fiber optics, Machine tool control, Vibration measurement

AF99-154 TITLE: Web-based Process Design Agents

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Capture interactions between disciplines and organizations, and therein, interdisciplinary relationships which enable collaborative engineering pursuits involving cost versus performance.

DESCRIPTION: A web-based cross-platform design environment, in a performance-based marketplace will facilitate profound changes on the design process - as we know it. Fundamental to that change is the perceived exponential growth in participants, not only from various disciplines within an organization or company, but up and down the multi-tiered supply chain - all of whom will have the opportunity to converge and engage each other on problems and solutions. The raw speed and potential voracity of such a global - 24 hour/day - design environment, given the undetered access by all who wish to participate, will be without precedence, and indeed, a paradigm shift in need of work-flow scheduling and dependency-tracking.
Few would argue that much remains to be learned regarding the process of design or re-design regarding spares production. We are told that design, as a process, is an expertise which is acquired through years of experience, and inspite of sundry efforts, little is known of what is truly generic, and thus universal, in support of a science. Given the formidable data gathering problems associated with capturing salient design knowledge across a diverse set of applications, cultures, etc., and the frustrations which surround issues such as the protection of intellectual property, a web-based design environment affords an opportunity to overcome these obstacles and exploit a technology referred to as agents to efficaciously gather, organize, compare and classify activities, sequences, information and their types, and potentially afford us needed expertise in the form of a video - simulation of the ideal process for our design problem.

PHASE I: Demonstrate the feasibility of pattern formation capability across a broad range of product and/or process designs ranging from bulk materials for structures to multi-layer thin-film interfaces, i.e., inter-layer and film-to-substrate, for tribological, temperature/oxidation resistance and electro-optical coatings. Materials of immediate interest are for performance enhancement and/or sustainment of aging aircraft to include high temperature intermetallics, composites, and inorganic electro-optical materials.

PHASE II:Develop a generic capability for near real-time monitoring and pattern formation across a broad range of component design materials and processes (defense and commercial) and demonstrate the discovery of patterns which suggest preferred methods, sequences and disciplines which optimize design cost and quality.

PHASE III DUAL USE APPLICATIONS: Dual use of this exploratory research is foreseen for the design of systems, more specifically, complex systems for automotive, aircraft, and/or space.

REFERENCES:
1. Jeffrey V. Zweber, Max Blair, Geetha Bharatram, Hilmi Kamhawi, Structural and Manufacturing Analysis of a Wing Using the Adaptive Modeling Language, AIAA Paper 98-1758, 39th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference on 20-23 April 1998 at Long Beach, CA.
2. Anand, S., Bell, D., Hughes, J., EDM: A general framework for Data Mining based on Evidence Theory, Data Knowledge and Knowledge Engineering, Apr 1996.
3. Heckerman, D., Bayesian Networks for Data Mining, Data Mining and Knowledge Discovery, Vol. 1 Issue 1, March 1997.

KEYWORDS: Design, Process, Materials, Autonomous Agents, Pattern Formation

AF99-155 TITLE: Advanced Resin System for RTM/VARTM Processing

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: To develop a low temperature cure resin system tailored for Resin Transfer Molding (RTM) and Vacuum Assisted Resin Transfer Molding (VARTM)

DESCRIPTION: RTM and VARTM processing of composite parts have been implemented on numerous commercial and military contracts; however, current applications are based on resin systems that cure at 350F and have service temperatures in the 250-350F range. While this is good enough for many applications, the full benefits of RTM/VARTM will not be realized without resins more tailored to the processes. Resin systems are needed that have low viscosity at room temperature for infusion, low cure temperatures (<180F) for low cost tooling applications, and freestanding post cures for E-beam or non-autoclave curing. This topic will support the Composites Affordability Initiative (CAI), a government/industry team focused on developing the tools and technologies necessary to enable future innovative designs for composite aircraft.

PHASE I: Develop a promising resin system using current aerospace resin systems as a baseline. Preliminary investigations should include viscosity data, curing data, post cure data, and initial data on process repeatability. Coupons will be fabricated and tested as to determine their potential towards topic resolution.

PHASE II:Further develop the resin system and demonstrate it on a military aerospace application. Data will be collected to further characterize the resin system. Both E-beam and oven post cure methods will be demonstrated during the Phase II effort.

PHASE III DUAL USE APPLICATIONS: The developed resin system will have military applications for processing of advanced composite aerospace components as well as other applications for land and sea based military craft. There is also a large commercial base in the areas of marine craft, recreational equipment, automotive, transportation, and various other markets that currently use composite RTM structures.

REFERENCES:
1. Composites Affordability Initiative Overview, (web site or DTIC white paper to be added).
2. Binetruy, C.; Hilaire, B.; and Pabiot, J (1998), "Tow Impregnation Model and Void Formulation Mechanisms during RTM." Journal of Composite Materials, Vol. 32, 223-245.
3. Lebrun, G.; Gauvin, R; and Kendall, K. N. (1996), "Experimental Investigation of Resin Temperature during Filling and Curing in Epoxy and Nickel Shell RTM Molds." Journal of Materials Processing & Manufacturing, Vol. 5, 27-44.

KEYWORDS: Resin, Curing, Processing, Composites, Vacuum Assisted RTM (VARTM), Resin Transfer Molding (RTM)

AF99-156 TITLE: Gate-All-Around SOI for Space Applications

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop a gate-all-around (GAA) silicon on insulator (SOI) process compatible with conventional complimentary metal-oxide semiconductor (CMOS) processing.

DESCRIPTION: The gate-all-around (GAA) SOI MOSFET (metal-oxide semiconductor field effect transistor) is a MOS (metal-oxide semiconductor) device completely surrounded by its gate. The performance of the GAA SOI MOSFET is improved relative to a conventional bulk or SOI MOSFET due to its increased active surface area, and thus greater transconductance. In addition, elimination of the back interface greatly improves the total dose radiation hardness of SOI MOSFET's by eliminating any leakage current path between source and drain. Latchup is not an issue in SOI circuits because of the ideal device isolation, and single-event upset is reduced due to the reduced collection volume beneath the source and drain. Thus the GAA SOI technology should be ideal for space applications. A GAA structure can be manufactured by forming a gate pattern in polysilicon over an SOI wafer, then overcoating the wafer with an insulator, planarizing the insulator, flipping and bonding the insulator to another wafer, stripping the underlying substrate from the original wafer, and completing the top gate and metal layers using a conventional CMOS process. The objective of this project is to develop a cost effective, reliable GAA SOI MOSFET integrated circuit manufacturing process suitable to produce space qualified hardware.

PHASE I: Develop a bottom gate formation and wafer bonding technique and combine with a conventional CMOS process to form a GAA SOI process. Produce a basic/prototype GAA SOI device and demonstrate operability in a "non-space" environment.

PHASE II:Finalize the Phase I GAA SOI production process. Fabricate (mutually agreed) production prototype GAA SOI devices. Demonstrate the capabilities/radiation hardness of the GAA SOI process by performing qualification testing, including total-dose, single-event upset, and latchup, on the production prototype structures.

PHASE III DUAL USE APPLICATIONS: The GAA SOI process will enhance the speed performance and reduce the leakage currents of all SOI technologies, military, space, and commercial. The low leakage currents and high speed of the GAA technique will have special importance for SOI dynamic random access memories, (DRAM's).

REFERENCES:
1. J.P. Colinge et al., Silicon-on-Insulator Gate-All-Around Device, IEDM Tech. Dig., pp. 595-598, 1990.
2. P. Francis et al., Temporal Analysis of SEU in SOI/GAA SRAMs, IEEE Trans. Nuc. Sci, 42, 2127 (1995).
3. D.C. Mayer and K.P. MacWilliams, Silicon-on-Insulator Gate-All-Around MOSFET Devices and Fabrication Methods, US Patent No. 5, 497,019, March 1996.

KEYWORDS: CMOS, MOSFET, Gate-All-Around, Transconductance, Radiation Tolerant, Silicon-on-Insulator

AF99-157 TITLE: Singularity/Boundary Layer Approach for Composite Joints with Discrete Damage

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Development of a 3-D singularity/boundary layer analysis tool for bolted/bonded composite joints with discrete cracks.

DESCRIPTION: The analyses of composite bolted joints and bonded joints present some of the most important and difficult tasks confronting designers of advanced airframes. In collaboration with a number of prominent airframe manufacturers, the Structural Materials Branch (WL/MLBC) of the Materials Directorate, AF Research Laboratory is engaged in a program to improve the stress analysis of bolted and bonded composite joints. The novel method to be developed for the present SBIR effort shall potentially offer more speed and flexibility in modeling joints of complex geometries, for structural engineering applications, than is possible using present methods. The required analyses for both phases shall be limited to linear elastic material responses. Although the critical phenomena to be modeled are localized, the software must produce accurate, full-field solutions over the entire domain.

It is strongly recommended that the proposal include graphical representations of the stress solutions of a boundary value problem involving at least two discrete elastic layers of dissimilar properties. Incorporation of singular behavior is encouraged. The solutions must be obtained using a novel numerical method. Methods already recognized as established engineering tools will not be viable candidates.

PHASE I: Development expertise shall be demonstrated by obtaining the solutions of difficult boundary value problems in layered elasticity, involving such features as free edges, cracks, and possibly 3-D fields. Layers and cracks shall be modeled discretely. The contractor shall, in addition, demonstrate the capability of generalizing the method to 3-D analyses of laminated bodies having anisotropic layers, interacting cracks and arbitrary geometries, according to the Phase II criteria stated below.

PHASE II: A 3-D analysis method meeting all of the criteria stated below shall be developed, and the solutions and computer code shall be made available to the Air Force and other DoD organizations. The computer program shall meet the following requirements:

1. The 3-D stresses and strains at arbitrarily specified points and the potential and strain energies of the body are the required outputs.
2. Joints are constructed of laminated composite materials; each lamina shall be discretely modeled, i.e., modeling using effective laminate properties is not permitted.
3. Bolted joints shall include a countersunk bolt-loaded hole with clamping stresses; elastic deformation of the bolt shall be treated and the contact zones shall be correctly evaluated.
4. Multiple, interacting cracks shall be included as discrete traction-free surfaces.
5. The program shall be readily adaptable to arbitrary geometries and loadings.
6. The program shall be implemented on a deskside-type workstation and have an execution time practical for engineering designers in the field, for laminates comprised of no fewer than 30 plies of arbitrary orientations.

PHASE III DUAL USE APPLICATIONS: The potential exists for a user-friendly, interactive computer code that can accurately predict progressive damage and failure of composite bolted joints of arbitrary geometries, and can aid in load-carrying assessments of bonded joints. As conceived, the end product will be a powerful analysis tool with wide applicability and high demand in the commercial and military aerospace industries, as well as in other industries where composites are utilized, such as automotive, power generation, marine and sporting goods.

REFERENCES:

1. Lund, J. and Bowers, K. L. (1992), Sinc Methods for Quadrature and Differential Equations, SIAM, Philadelphia.
2. Stenger, F. (1993), Numerical Methods Based on Sinc and Analytic Functions, Springer-Verlag, New York.

KEYWORDS: Singularity, Boundary layer, 3-D stress, Bolted joints, Bonded joints, Composite material

AF99-158 TITLE: Electrically Conductive, Optically Transparent Polymeric Coating for Canopy ESD Protection

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Design, synthesize, and develop novel transparent conductive organic polymeric materials to be processed in monolayer film by state-of-the-art methods for aircraft canopy electrostatic charge dissipation (ESD).

DESCRIPTION: Electrostatic charge build-up caused by frictional as well as static forces upon state-of-the-art canopy substrate materials has caused considerable documented damage to coated, laminated canopies. Current ESD materials possess acceptable static conductivities but suffer from lack of physical integrity and mechanical robustness in thin film form. Organic polymers may provide that mechanical integrity for the conductive coating. Organic polymers are also more similar to the substrate plastics in chemical composition or can be tailored by the addition of functional chemical groups to be more like the substrates so that adhesion is improved. Expertise is sought for the preparation and pertinent testing of novel conductive monolayer organic polymer compositions which are compatible with current canopy substrate materials and are electrically continuous, thermooxidatively stable, and durable (i.e., environmentally stable, mechanically robust). Previous canopy efforts have focused on blends of known conducting polymers, such as polyaniline, in an effort to form a composite film. Recent scientific advances, however, have demonstrated by atomic force microscopy that truly monolayer (one molecule thick) films of conductive polymers can be formed on glass and silicon substrates, and that such films are electrically contiguous. Some monolayer films have been shown to be so mechanically robust that they cannot be removed from the substrates even with vigorous mechanical force. The aim of this solicitation is to develop this discovery further toward application on aircraft canopies. Anticipated advantages of this technology would be little or no degradation in overall canopy optical performances and no measurable additional weight to the canopy - both of which are anticipated natural consequences of the coatings being only one molecule thick.

PHASE I: The goals of the Phase I effort shall include the preparation of novel aromatic or heteroaromatic polymers with direct current (DC) surface conductivities in the range of 10-5 to 10-8 S/cm as monolayer (one molecule thick) films measured by four-point probe, van der Pauw or other similar methods. The ability to prepare the monolayer by an accepted low temperature coating method such as sol-gel, Langmuir-Blodgett, or other flowcoating techniques will greatly reduce the costs of processing the final polymer composition and accelerate the technical transition of the candidate material. The methods by which to evaluate the successful conductive monolayer candidate include the test methods previously cited, determination of coating profile on substrates, differential scanning calorimetry and thermogravimetric analysis for basic polymer thermoanalytical properties, and characterization of basic physical properties of the polymer by determination of molecular weight and solution viscosity. A key element of Phase I includes the demonstration that electrically contiguous monolayer films can be formed on polycarbonate substrates.

PHASE II: In Phase II of the effort the technical work shall require the preparation of up to 450 grams of polymer under reproducible conditions based on the technology developed in Phase I. Evaluation of the optical quality and durability of the processed materials shall involve tests such as QUV; luminous transmittance, haze, and yellowness index although it is anticipated that optical quality will not be a major issue if true monolayers are obtained. Chemistries and processes shall be developed to maximize mechanical robustness as measured by standardized ASTM abrasion tests on various substrates and solvent crazing under load. Full thermoanalytical, thermomechanical and rheological characterization shall also be required. Deliverables of the candidate polymer on 2 ft2 X « inch thick optical grade polycarbonate sheet shall be required at the conclusion of the Phase II effort.

PHASE III DUAL USE APPLICATIONS: Dual use potential exists for the successful composition and process that optimizes low production cost. Commercial applications would include ESD coatings for minimizing charge build-up on transparencies in bead blast booths that are used to remove conformal coatings from electronic boards and ESD coatings for minimization of tribocharging on television and computer CRT screens.

REFERENCES:

1. DTIC AD-A330-165 (1997) and DTIC AD-A264-751 (1993) (Unclassified, unlimited).
2. A. Tracz et al., Syn. Met. 86 (1-3), pt 3, 2173 (1997).
3. V. G. Kulkarni, Proceedings: Conf. Plast. For Portable and Wireless Electronics, Soc. Plast. Eng., 18 (1997).
4. V. G. Kulkarni et al., Elect. Overstress/Electrostatic Discharge Symp. Proc., 225 (1995).

KEYWORDS: Aircraft transparencies, conductive polymers, electrostatic discharge, monolayer, flowcoat, films.

AF99-159 TITLE: Lubrication in Extreme Environments

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop lubrication systems capable of operating for long periods of time in extreme (hostile) environments.

DESCRIPTION: Air Force systems are required to operate in hostile environments for increasing time periods. They are expected to have long life and consistently provide high performance. Materials are under development to meet some of these needs, but lubrication and wear control technology are lagging behind. This topic is focused on addressing these lubrication issues. Miniaturization of components and functions is of critical importance as the AF increasingly relies on space borne systems and unmanned air vehicles. Microelectromechanical systems (MEMS) hold the potential for significant advancements in these areas as well as providing a sensor capability for health monitoring, which will extend lifetime and reduce life cycle costs by permitting a move toward "as needed" as opposed to "scheduled" maintenance. Specific devices incorporating MEMS include motors, gyros, microwave switches, phased arrays, etc., as well as a variety of sensors including optical, chemical, electronic, etc.. However, friction and wear problems prevent the realization of some MEMS devices and reduce the performance of others. MEMS devices present one of the most challenging hostile environments because they are processed and packaged similar to semiconductors. Proposals on new materials, coatings, and surface treatments (e.g., self-assembled monolayers) for lubrication and wear control of MEMS devices are sought. Turbine engine environments are also hostile; engines are required to operate at increasingly higher temperatures to improve aircraft efficiency and performance. Oils that operate above 288 C without undergoing significant coking or degradation are not available. Perfluoropolyalkylethers are good candidates, but they degrade at high temperature in the presence of metal alloys, particularly those containing iron. The degradation products attack the alloys, thus destroying the lubrication system. Ceramic systems are also degraded. Proposals using a systems approach (considering the bearing balls, races, cages, corrosion resistant coatings, surface treatments, lubricants and performance enhancing additives) are encouraged.

PHASE I: Develop a viable approach and determine the materials and/or materials combinations to address the key elements of one of the research and development areas described above .

PHASE II:Follow-on efforts in Phase II will further develop and optimize the materials, coatings, surface treatments, and/or complete lubrication systems using the approaches established in Phase I.

PHASE III DUAL USE APPLICATIONS: The materials and technology developed under this program would have numerous dual use applications. The commercial aircraft and spacecraft industries will benefit because the technology developed will be directly applicable to their needs for reduced size and weight. Any industry in which miniaturization is important, or that uses sensors in a critical application may also benefit.

REFERENCES:
1. "Microelectromechanical Systems: Advanced Materials and Fabrication Methods," NMAB-483, National Academy Press, Washington, DC 1997.
2. "Advanced Hard Coatings and Wear Resistant Materials for Aerospace Systems," J.S. Zabinski, A.A. Voevodin, and M.A. Capano, AGARD-CP-589, 1996. [ADA 318971 (Article 4)-NTIS]
3. "Soluble Additives for Perfluoropolyalkylether Liquid Lubricants," Lubrication Eng., V49, 702-708 (1993).

KEYWORDS: Oils, Coatings, Lubricants, Surface treatments, Lubricant additives, Self-assembled monolayers, Lubricated spacecraft mechanisms, Microelectromechanical systems (MEMS)

AF99-160 TITLE: Carbon-Reinforced Composites for 550 to 1200 degrees F Applications

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: To develop affordable carbon-reinforced polymer (PMC) or carbon (C-C) matrix composite materials and processes for 550 to 1200øF applications.

DESCRIPTION: The Air Force is seeking new and highly innovative concepts for affordable processing approaches and materials for carbon-reinforced PMC and C-C. Current and future Air Force applications require high temperature performance in the range of 550 to 1200øF with oxidation and chemical stability of 1000 hours. These applications include: aircraft and launch vehicle engine components; aircraft primary structures, engine cells, environmental heat exchangers, and other thermal management systems. Titanium is typically used for these applications because it is lightweight, exhibits good structural properties and is reasonably corrosion resistant. Other materials include INCONEL , which are heavy and moderately expensive. Before a composite part could replace a titanium or INCONEL part, processing costs and starting material's cost must be reduced. Therefore, innovative concepts utilizing lower cost materials, with the objective of reducing life cycle material cost by an order of magnitude, lower cost high conductivity fibers, improved oxidation resistant systems and high temperature bagging and sealants are solicited. These materials must be suitable with low cost processing technologies such as, resin transfer molding (RTM), vacuum-assisted resin transfer molding (VARTM), tow placement, near net shape or one-step manufacturing. This temperature range is not inclusive for all applications, i.e., some may require 550-800øF while others may need 1000-1200øF materials. The specific application requirements will define the type of composite matrix that will be required, i.e.; the lower temperature will probably utilize a polymer matrix composite while the higher temperatures will demand a carbon matrix. But regardless of the matrix material, the composite component must be affordable and easily processed compared to the titanium or INCONEL part to be replaced.

PHASE I: The Phase I program must demonstrate the feasibility and cost savings of the proposed concept for the PMC or C-C sufficient to justify further development and/or scale-up in a Phase II effort. Proof-of-concept includes demonstration of oxidation/chemical stability and/or processability of specimens or small sub-components. In addition, the materials shall be evaluated to prove they can meet the specific properties of titanium or INCONEL in an equivalent service environment.

PHASE II: The concepts demonstrated in Phase I will be scaled up and developed in detail. The payoffs and benefits of the technology will be demonstrated by fabrication, processing and characterization of a component or subcomponent.

PHASE III DUAL USE APPLICATIONS: A variety of aircraft, spacecraft and launch vehicle applications (commercial and DOD) use high temperature structural materials. Demonstration of a lighter weight, lower cost alternative would provide tremendous savings for aircraft heat exchangers, aircraft and launch vehicle engine components, aircraft fuselage, wing and tail structures, as well as engine cells.

REFERENCES: G. Savage, "Carbon-Carbon Composites", Chapman & Hall, 1993. 43rd International SAMPE Symposium, Anaheim CA, 1998. 42nd International SAMPE Symposium, Anaheim CA, 1997.

KEYWORDS: 550 to 1200øF composites, high temperature bagging and sealant materials, affordable resins and processing, oxidation/chemical stability, polymer matrix composites, carbon-carbon composites.

AF99-161 TITLE: Epitaxial Growth of Silicon Carbide (SiC)

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Develop advanced, innovative epitaxial processes for the growth of silicon carbide for electronic applications.

DESCRIPTION: Advanced Air Force systems will require new and novel semiconducting materials to meet challenging power, frequency, speed, and temperature requirements. Conventional semiconductors such as bulk silicon and gallium arsenide cannot meet these requirements. Silicon carbide has many unique properties such as wide band gap, high breakdown field and physical strength, which make it attractive for high temperature and high power applications. This task seeks to develop improved and innovative approaches for the growth of single crystal epitaxial silicon carbide. Homoepitaxy of 6H- and 4H-SiC are of primary interest, however heteroepitaxy of other SiC polytypes on SiC substrates will be considered. Amorphous SiC and SiC-on-silicon will not be considered under this solicitation. Growth of SiC for protective or thermal coatings or other surfaces such as mirrors is not considered applicable to this topic. Projects that are primarily device development or device processing will also be considered nonresponsive.

PHASE I: Phase I will address process development and initial testing to show proof of concept. Phase I goals shall include confirmed homo- and/or heteroepitaxial growth. Additionally, epitaxial thickness and thickness variation goals for Phase I shall be commensurate with ultimate requirements for future device and electronic structures development. Modeling studies of growth processes or materials properties are appropriate. A deliverable of a representative test sample to the government is encouraged.

PHASE II: Phase II will develop the advanced semiconducting materials and/or processes to demonstrate the potential application. Phase II goals shall reflect state-of-the-art parameters for epitaxial growth including but not limited to total epitaxial thickness variation of less than 2% across growth substrate and, if applicable, total doping concentration variations less than 2% across growth substrate. Additionally, a goal for total epitaxial macroscopic defects shall be less than 1 per square centimeter. Modeling studies of growth processes or materials properties are appropriate. Deliverables of test materials to the government for evaluation are encouraged.

PHASE III DUAL USE APPLICATIONS: Microwave devices made from SiC will exhibit high power, high frequency operation (e.g. 20 watts in X-band at room temperature) with higher package density and reduced cooling subsystem requirements. In addition, the high temperature nature of SiC permits the development of a host of harsh environment electronic devices. SiC electronics have many commercial applications. The automotive industry needs reliable materials and devices for the high temperature, corrosive, dirty environment in an automotive engine. Additionally, one of the planned uses in military aircraft, namely, on-engine flame detectors (i.e. in the engine during flight) is directly transferable to civilian aircraft. The development of improved epitaxial growth processes for SiC will be required to successfully commercialize these high temperature, high power devices.

REFERENCE: "Mechanical Properties of Semiconductors and Their Alloys," SRI Inc, AD No: A231820.

KEYWORDS: Silicon Carbide, Materials, Epitaxy, Crystal Growth

AF99-162 TITLE: High-Efficiency Dynamic Holographic Materials

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop new materials having real-time holography applications.

DESCRIPTION: High efficiency dynamic holographic materials (HEDHM) are optical materials having application in real-time holography. A HEDHM material contains photochromic dyes that undergo large birefringence changes upon irradiation. A grating written on this material has high hologram efficiency. Unlike static holograms, dynamic holograms decay with a user-defined half-life varying from seconds to hours. Therefore, HEDHMs have application in optically switchable reflection holography, schlerien optics, spatial light modulators and optical data storage. An example of a potential HEDHM is the photochromic polypeptide, which undergoes light-induced coil to helix transition followed by dark adaptation. If the polypeptide has a monodisperse molecular weight distribution, higher grating efficiency is possible through the greater ordering of the material. A second example is bacteriorhodopsin. Bacteriorhodopsin has been used in real-time holography, although the efficiency is low. If the hologram efficiency can be raised, the utility of bacteriorhodopisin would increase. A third example combines photochromism and liquid crystal optics. For laser protection, HEDHMs would be used as an optically switchable holographic mirror where an unknown threat laser would write a holographic mirror, thereby reflecting the light. When the threat is inactive, the mirror would decay. Proposals submitted to this topic should clearly address the applications where this device technology could be applied; however, the content of the program should focus on materials and process development - not device demonstration.

PHASE I: During this phase the offeror will demonstrate the feasibility of the materials or processes to give a proof of principle and identify those materials/processes issues which must be addressed during Phase II of the program.

PHASE II:Optimize the materials and/or processes to achieve performance or capabilities not currently available. Design, fabricate and characterize a test article based on the developed materials or processes which demonstrate an advance in the state of the art in real-time holography.

PHASE III DUAL USE APPLICATIONS: Holographic materials have numerous commercial applications. Examples of applications for high efficiency dynamic holographic materials include display technology, optical data storage and spatial light modulators.

REFERENCES:
1. Cooper, T.M. Mol. Cryst. Liq. Cryst. 298: 197-203(1997).
2. Cooper, T.M., Natarajan, L.V. Trends. Polym. Sci. 1: 400-405(1993).

KEYWORDS: Holography, Photochromism, Dynamic Holography, Holographic Materials, Photochromic Polymers, Photochromic Polypeptides

AF99-163 TITLE: Materials for Superlattice Infrared Detectors

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Research and development of innovative epitaxial growth techniques for III-V superlattice materials with controlled mixed anion interfaces.

DESCRIPTION: The Air Force requires new very long wavelength infrared (VLWIR) detectors with increased operating temperature and improved detectivity for space based applications. These detectors will be required to operate over a wide range of wavelengths including those beyond 16 micrometers. The presently available detectors are extrinsic silicon. Due to excessive dark current, the operating temperature of these detectors is below 20K. Detectors with increased operating temperatures with equivalent or better detectivity will have significantly reduced launch costs due to reductions in the weight of the cryocooler. The principal alternatives to extrinsic silicon at present are compound semiconductor superlattices based on group III antimonides and arsenides. Detector structures have been fabricated from InGaSb/InAs and InAsSb/InSb superlattices but the performance has not been adequate. This task seeks to develop improved and innovative epitaxial growth techniques for growing superlattices based on mixed anion interfaces such as InGaSb/InAs. Both molecular beam epitaxy (MBE) and metal organic chemical vapor deposition (MOCVD) will be considered as well as other novel growth techniques. It is expected that improvements will be made in interface purity, abruptness and smoothness. Growth on novel substrates is encouraged.

PHASE I: Phase I will address process development and growth of simple heterointerfaces along with the minimum characterization to demonstrate improved interfaces. A deliverable of a representative test sample to the government is encouraged.

PHASE II:Phase II will optimize the growth process demonstrated in Phase I with more extensive characterization. Modeling of the growth process or superlattice properties are appropriate. Growth and evaluation of superlattice structures suitable for VLWIR detectors will be used to demonstrate the success of the program. Delivery of test materials to the government for evaluation is encouraged.

PHASE III DUAL USE APPLICATIONS: Structures based on mixed anion heterointerfaces have applications in a wide variety of electronic and opto-electronic areas. In particular, room temperature operating infrared detectors based on III-V semiconductor superlattices or multiple quantum wells are of interest to the automotive and aviation industries, among others. Microwave transistors based on mixed anion heterointerfaces have application in many commercial areas such as cellular phones, and direct broadcast satellite television.

REFERENCE: J. L. Johnson, L. A. Samoska, A. C. Gossard, J. L. Merz, M. D. M. Jack, G. R. Chapman, B. A. Baumgratza, K. Kosai, and S. M. Johnson, Journal of Applied Physics Vol. 80, Pg. 1116 (1996).

KEYWORDS: Epitaxy, Infrared, Materials, Superlattice, Semiconductor, Hetero-Interfaces

AF99-164 TITLE: Absorbing Dyes with Improved Properties

TECHNOLOGY AREA: Sensors

OBJECTIVE: Synthesize injection moldable dyes with enhanced performance, large extinction coefficients, narrow spectral bandwidths, with improved performance and utility for laser eye protection applications.

DESCRIPTION: Laser eye protection devices are based upon a variety of absorbing and reflecting technologies that provide control of energy reaching the eye. There is a continuing need for cost effective alternatives to reflective technologies such as dyes that absorb energy at selective wavelengths. Additionally, for reflecting technologies that are becoming more affordable and ubiquitous, dyes are used, individually or in combination, to manage narcissistic back reflections. There is a need for dyes that can provide high attenuation to specific wavelengths, higher transmittance off peak absorption and greater robustness to environmental variables such as manufacturing processing conditions. The technological shortfalls preventing wider implementation of dye based eye protection includes; poor UV stability; degradation at elevated injection molding processing temperatures; fluorescence; and reversible bleaching effects at high irradiation levels. The objective of this topic is to synthesize new dyes with symmetrical absorption profiles with very low off-peak absorption, no satellite peaks and no Soret absorption bands are desirable. Examples of research and development efforts appropriate to this topic are 1) the synthesis and incorporation into polycarbonate and 2) evaluation of one or more new dyes that overcome the deficiencies noted with properties such as those in table 1.

Table 1. Materials Research Goals for Synthesized Dyes
Wavelengths of Interest(nm) Extinction Coefficient Bandwidth FWHM @ OD=2 Temperature Stability Luminous Transmittance
500, 532, 560, 590, 694 |50000 £20nm 485 F and 565 F | 75%
1300 |50000 >50 nm 485 F and 565 F | 75%

The full width half maximum bandwidth applies for a peak OD=3.
Proposals submitted to this topic must clearly address the end item application for which the dyes are used, the interaction of process variables involved and provide example dye/host material witness samples. The emphasis, however, is on synthesis and characterization of one or more dyes with improved performance.

PHASE I: During this phase, the offerer will demonstrate the feasibility of synthesizing one or more of the materials (dye in host), and identify those issues which must be addressed during Phase II of the program.

PHASE II: Optimize the dye(s) using Table 1 values as requirements. Design and deliver characterized prototype protective devices in ophthalmic quality lens spectacle format and in ophthalmic quality visor format based upon improved dyes. Demonstrate producibility through pilot level production of 200 lens blanks and 100 visors.

PHASE III DUAL USE APPLICATIONS: Laser eye protective devices are required for a wide variety of laboratory and military personnel protection applications.

KEYWORDS: Porphyrins, Dithiolenes, Polycarbonate, Absorbing dyes, Optical filters, Injection molding, Phthaloalocyanines, Laser eye protection

AF99-165 TITLE: SOI Material for High Reliability Space Systems

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop an SOI screening methodology that will enable highly reliable gate oxides in SOI microcircuits.

DESCRIPTION: The development of SOI (silicon on insulator) technology and its incorporation into space systems has been hampered by unacceptably poor gate oxide integrity caused by defects, impurities, and surface roughness in the starting SOI material. These defects can reduce the yield and subsequent reliability of integrated circuits manufactured using SOI materials. A methodology/technology for early quantitative detection/evaluation of SOI failure related material characteristics is required. An analytical material evaluation process will support the improvement of SOI starting material quality and facilitate evaluation of the reliability of very thin gate oxides (grown on variously constructed SOI films) as a function of the defect types that generate the observed oxide failures.

PHASE I: In this phase, a test methodology will be developed that will quantitatively assess the quality and reliability of gate oxides grown on silicon-on-insulator films. The methodology shall be demonstrated through data obtained by growing and stressing thin oxides on SOI films to failure by conventional time-dependent dielectric breakdown techniques, and characterizing the resulting failure sites as (among others) defect-, roughness-, or contaminant-related.

PHASE II:In this phase, the test methodology shall be finalized, test equipment necessary to implement the technique will be procured/constructed and the methodology shall be statistically validated by sufficient data (similar to the data described in Phase I supplied through Air Force assistance.

PHASE III DUAL USE APPLICATIONS: The gate oxide stress measurement technique can be applied to SOI starting material for both space qualified military and commercial SOI products. This technique will enable the widespread usage of SOI material for all applications, including space as well as ground-based systems. Current commercial suppliers of SOI products have evidenced high interest in development of this technology.

REFERENCES:

1. S.Q. Hong et al., Integrity of Gate Oxide on TFSOI Materials, in Proceedings 1995 IEEE Int. SOI Conf., Oct. 1995, pp. 22-23.
2. S.R. Wilson et al., Materials, Device and Gate Oxide Integrity Evaluation of SIMOX and Bonded SOI Wafers, in Proceedings 1995 IEEE Int. SOI Conf., Oct. 1995, pp. 143-145.
3. G. Brown et al., Integrity of Gate Oxides Formed on SIMOX Wafers, in Proceedings 1994 IEEE Int. SOI Conf., Oct. 1994, pp. 73-74.

KEYWORDS: SOI, silicon, insulator, gate oxides

AF99-166 TITLE: Frequency Conversion and Electro-Optical Materials

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Develop new nonlinear optical materials with superior properties as compared to those presently available.

DESCRIPTION: Nonlinear optical (NLO) materials are required for a variety of Air Force appli-cations including infrared countermeasures, remote sensing of chemical and biological agents, optical communications, and optical interconnects. These applications require new laser sources (optical parametric oscillators and harmonic genera-tors) and electro-optic devices (directional couplers, guided-wave interferometers, and optical phase shifters). However, presently available materials are unsatisfactory for many applications due to small nonlinearities, poor optical clarity, difficulty in process-ing for devices, vulnerability to environmental degradation, and other factors. Proposed efforts shall address inorganic or organic materials in bulk or thin-film forms, which exhibit large second-order nonlinear effects. Strongest interest is (1) in bulk crystals eventually capable of handling average output powers greater than 10 watts for frequency conversion to the 2- to 12-micron wavelength range and (2) in thin films for guided-wave devices in the 0.7- to 1.55-micron range. Innovative tech-niques for preparing new materials are encouraged. Currently available materials such as periodically-poled lithium niobate (PPLN) are outside the scope of this topic. Nonlinear optical devices may be examined only as a minor part of a materials effort to evaluate and demonstrate the properties of the material(s).

PHASE I: The objective is to demonstrate a new material, the feasibility of a proposed new growth technique, improved functionality of a material through innovative processing techniques, or improved materials properties resulting from either growth or processing advancements.

PHASE II: The objective is to further develop the proposed material and / or the relevant processes to fully demonstrate the materials properties and usefulness for commercial and military applications. Establish all necessary manufacturing processes for commercialization of a product.

PHASE III DUAL USE APPLICATIONS: Materials technology is fundamental to all applications, military and commercial. Examples of commercial applications for NLO bulk crystals are LIDAR for environmental monitoring, medical lasers, and scientific instruments. Examples for NLO thin films are optical switches for cable TV, optical phase shifters for phased array radar; optical interconnects for electronic packages, and switching networks for communications.

REFERENCES:

1. Bordui, Peter F. and Martin M. Fejer, "Inorganic Crystals for Nonlinear Optical Frequency Conversion," Annual Review of Materials Science (Volume 23), ed. Robert A. Laudise et al, Annual Reviews Inc, 1993

2. Dmitriev, V.G. , G.G. Gurzadyan, and D.N. Nikogosyan, Handbook of Nonlinear Optical Crystals 2nd Edition, Springer-Verlag, 1997.

3. Baumgartner, R.A. and R.L. Byer, "Optical Parametric Amplification," IEEE Journal of Quantum Electronics QE-15 (1979), pp. 432-444.

4. Lackritz, Hilary S. and John M. Torkelson, "Polymer Physics of Poled Polymers for Second-Order Nonlinear Optics," Molecular Nonlinear Optics. Academic Press, 1994.

5. Ghosh, Gorachand, Handbook of Thermo-Optic Coefficients of Optical Materials with Applications, Academic Press, 1998.

KEYWORDS: Nonlinear optical materials, NLO materials, electro-optic materials, optical signal processing, second harmonic generation, optical parametric oscillation, Pockels effect.

AF99-167 TITLE: Novel, Self-Cleaning Filter for Carbonaceous PM2.5 in Combustion Exhausts

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop and demonstrate a cost-effective technology that will remove soot from hot gas streams and convert it into environmentally benign products.

DESCRIPTION: Revisions to NAAQS being imposed under Title I of the Clean Air Act will require the application of effective measures to decrease tailpipe and stack emissions of combustion-derived particulate matter (soot). Modifications to the combustion process are expected to provide part of the solution, but options for effective, affordable control, which are the target of this solicitation, are also expected to be needed. The technology must be capable of extended (months) periods of unattended operation in a nonconstant operating environment, and (to allow for application to mobile systems) should fit within the dimensions of typical combustion sources that it is sized to control. Introduction of hazardous materials, use of high-tech methods, and loss plus consumption of more than 2% of the total power output of the source will be considered negative factors in selection.

PHASE I: Develop and conduct a bench-scale demonstration of the technical principle(s) upon which the control strategy is dependent. Perform a preliminary analysis of the estimated cost to apply the technology to one or more candidate sources. Develop a commercialization plan, identifying any partners and other resources.

PHASE II:After additional development, assemble and test a pilot-scale engineering model of the technology in a controlled environment. After any necessary modifications and adjustments, test the performance of the pilot system on an actual source (or a split of the exhaust from an actual source) at an operational site to be agreed upon with the POC. The test will include measurement of performance, treatment by-products, consumption of any added materials, energy usage, operator time, and any other factors contributing to costs. Data from the test will be used to perform a more-refined analysis of the cost of applying the technology to several general cases.

PHASE III DUAL USE APPLICATIONS: Dual-use potential for this technology is very high because a number of the DoD systems requiring control are commercially acquired and because it will also be applicable to many other commercial and private combustion systems, all of which are expected to come under pressure to decrease fine-particulate emissions.

REFERENCES:

1. Air Pollution Control Methods, Kirk|Othmer Encyclopedia 3rd Ed., pp. 766|825.
2. Sittig, M. [1977]. Particulates and Fine Dust Removal, Noyes Data Corp., pp. 510|512.
3. Bergman, W., Biermann, A.H., et al. [1983]. "Electrostatic Air Filters Generated by Electric Fields," Particulate Systems: Technology and Fundamentals, p. 57.

KEYWORDS: Soot, PM2.5, Combustion

AF99-168 TITLE: Perchlorate Sensing Technology

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop and demonstrate an in situ capability to detect and quantify perchlorate at the part per billion level in groundwater.

DESCRIPTION: For decades the US Air Force has used ammonium perchlorate as an oxidizer in rocket propellants. During the manufacturing process, waste streams containing varying concentrations of ammonium perchlorate have been discharged into the environment and have found their way into aquifers and drinking water sources. Testing methods have evolved to push the minimum detection level for perchlorate from the part per million level to the part per billion level. The Environmental Protection Agency has identified perchlorate as a hazardous contaminant and established an action threshold of 18 ppb. The current need is for a quick, inexpensive, field portable in situ capability to detect and quantify perchlorate in groundwater at the ppb level. Measurements are expected to support site characterization as well as long term monitoring. An ultimate goal is to integrate this capability with the E-SMART network of smart sensors.

PHASE I: Phase I will result in the laboratory demonstration of a technology and methodology to detect and quantify perchlorate in groundwater samples that has the potential for practical in situ application. The Phase I efforts will be documented in a technical report.

PHASE II:Phase II will develop an engineering model employing the capability demonstrated in Phase I, and demonstrating the device in a field situation. Phase II will include analysis of the unit cost, cost per measurement, and cost of ownership for the device. The Phase II effort will be documented in a technical report.

PHASE III DUAL USE APPLICATIONS: With the promulgation of the Safe Drinking Water Act, each provider of drinking water needs a capability to detect perchlorates. The immediate potential is for those drinking water providers near rocket propellant processing facilities.

REFERENCES:
1. ESOH Need 1927, "Additional information on ammonium perchlorate developmental bone marrow, and thyroid toxicology are needed to refine the human risk assessment."
http://xre22.brooks.af.mil/hscxre/97tns/97needs/1927.htm
2. High levels of perchlorate are detected in a monitoring well at the Kerr-McGee plant near Henderson.
3 . http://www.lvrj.com/lvrj_home/1997/Sep-05-Fri-1997/news/6005670.html

KEYWORDS: Sensing, Ammonium, Monitoring, Perchlorate, Groundwater, Rocket Propellant

AF99-169 TITLE: Advanced Coatings Systems

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Research and development leading to advanced aircraft coating systems capable of providing extended service lifetimes as defined below.

DESCRIPTION: Aircraft painting/stripping/repainting processes and handling the associated hazardous waste is one of the highest cost maintenance activities in the Air Force. The Air Force Coating System Strategy applies to almost all operational aircraft and identifies aircraft coating system requirements from now until beyond the year 2003. In addition to environmental compliance, the strategy clearly defines long term coating system performance parameters of 30+ years durability in corrosion protection and 8+ years durability for topcoats, which are significantly beyond the current state-of-the-art. These longer life and environmental requirements apply to both conventional aircraft coatings and specialty materials, such as optical coatings, used by the Air Force.

An advisory panel of internationally recognized experts in the fields of coating technology and corrosion science and engineering from industry and academia, was chartered to study the potential of a basic research contribution to ameliorate the aircraft paint issue. The panel recommendations lead to a programmatic course of action enabling for the Air Force to meet its stated objectives by the year 2003. The following three areas of research and development activity are currently underfunded and are herein identified for investment:

1. High durability, corrosion resistant surface treatments and permanent primer coatings capable of providing corrosion protection for a 30+ year life cycle using environmentally benign materials.
2. Identification of mechanisms of aircraft coating failures around rivets and panel edges, and other localized high strain areas of the aircraft leading to accelerated corrosion and topcoat damage. Results should lead to development of improved approaches to coatings and accelerated tests for evaluating surface treatments, primers and flat (matte) topcoats.
3. Demonstration of novel formulation/component concepts and materials (polymers, additives, pigments, corrosion inhibitors, etc.) for low/no VOC flat (matte) coating systems that will lead to formulation of coating systems providing improved cleanability, mar resistance, chemical resistance, rain erosion resistance, and lifetime.

Research and development programs are sought which address the unique operational requirement of a permanent 30-year corrosion surface treatment/primer protection life cycle and 8-year topcoat requirement.

PHASE I: The establishment of viable approaches to addressing key elements of the above three research and development areas are sought in Phase I.

PHASE II:Follow-on efforts in Phase II will further develop and optimize the elucidation of mechanisms, development of models, and/or synthesis of advanced materials using the approaches established in Phase I.

PHASE III DUAL USE APPLICATIONS: The commercial aircraft industry will benefit because much of the technology developed will be directly applicable. The auto industry also has a great need for corrosion protection as well as a need for predicting and extending the life of coatings for cars and trucks.

REFERENCES: SBIR Requirements Documents based upon the "Report of the AF Blue Advisory Panel on Aircraft Coatings, Part 1 - Basic Research", the Air Force Coating System Strategy draft "Operational Requirements Document" (ORD), and the "Advanced Performance Coating Document" will be available on the AFRL/ML web site.

KEYWORDS: Resin, Topcoat, Aircraft, Application, Formulation, Rain Erosion, Coating System

AF99-171 TITLE: Novel, Regenerable Filter for Dusts and Sticky Mists

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop and demonstrate a cost-effective technology that will remove fine dust and mist particles from a ventilation air stream with minimum waste generation or conversion of the captured particles into environmentally benign products.

DESCRIPTION: Revisions to NAAQS being imposed under Title I of the Clean Air Act will require the application of effective measures to decrease emissions of particulate matter finer than current technology is expected to manage. Modifications to (other than cessation of) the generating processes are not expected to contribute significantly to this reduction, so options for effective, affordable control are needed. Desirable qualities for the technology include capability of extended periods of unattended operation in a start-and-stop application, compactness, and minimal pressure loss. Use of exotic or hazardous materials, or requirement for unusual expertise to operate or maintain the technology will be considered negative factors in selection.

PHASE I: Develop and conduct a bench-scale demonstration of the technical principle(s) upon which the control strategy is dependent. Perform a preliminary analysis of the estimated cost to apply the technology to one or more candidate sources. Develop a commercialization plan, identifying any partners and other resources.

PHASE II:After additional development, assemble and test a pilot-scale engineering model of the technology in a controlled environment. After any necessary modifications and adjustments, test the performance of the pilot system on an actual source (or a split of the exhaust from an actual source) at an operational site to be agreed upon with the POC. The test will include measurement of performance, treatment by-products, consumption of any added materials, energy usage, operator time, and any other factors contributing to costs. Data from the test will be used to perform a more-refined analysis of the cost of applying the technology to several general cases.

PHASE III DUAL USE APPLICATIONS: Dual-use potential for this technology is very high because a number of the DoD systems requiring control are commercially acquired and because it will also be applicable to many other commercial and private environments (e.g., indoor air in buildings, transportation, and isolated enclosures; exhaust air from industrial and craft fabrication, finishing, and refinishing facilities), all of which are expected to come under pressure to decrease fine-particulate emissions.

REFERENCES:
1. Air Pollution Control Methods, Kirk|Othmer Encyclopedia 3rd Ed., pp. 766|825.
2. Sittig, M. [1977]. Particulates and Fine Dust Removal, Noyes Data Corp., pp. 510|512.
3. Bergman, W., Biermann, A.H., et al. [1983]. "Electrostatic Air Filters Generated by Electric Fields," Particulate Systems: Technology and Fundamentals, p. 57.

KEYWORDS: IAQ, PM2.5, Mists, Abrasive, Painting, Fine dusts

AF99-174 TITLE: Development of Highly Anti-Reflective Surfaces for Semiconductor Wafers

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Design and fabrication of high performance antireflection surfaces for infrared optical materials

DESCRIPTION: Semiconductor compounds and alloys such as mercury cadmium telluride (MCT) have important applications in the infrared, for example, as infrared detectors or as optical elements. High quality anti-reflection (AR) coating is desired for many of these applications. Traditional method AR coating, the evaporation of thin films on to semiconductor surfaces, is made difficult by the fact that the optimal substrate temperature is often higher than the temperature at which significant degradation of the material starts to occur. Also, the thin film coatings are often unable to withstand a large number of cycles between room and cryogenic temperatures. An alternative way to obtain high performance, antireflection effect over desired wavelength ranges is to use surface structure modification (1,2). This technique provides an additional advantage in that it obviates the need to use complicated coating designs often involving radioactive materials. Moreover, these surfaces would exhibit intrinsically hard laser damage performance in high-power laser applications. Proposals are solicited to develop the technique and to provide high quality AR surfaces with average reflectivity < 5 % in the 3 - 5 micron and in the 8 - 12 micron spectral ranges, on semiconductor materials that cannot be heated beyond 45 - 50 degrees C.

PHASE I: During this phase the offeror will evaluate the design trade-offs based on various fabrication (especially etching) techniques available and perform preliminary proof-of-concept validation experiments.

PHASE II: Optimize the processes to achieve performance or capabilities not currently available. Design, fabricate and characterize a test article based on the developed process which demonstrates an advance in the state-of-the-art surface modification method.

PHASE III DUAL USE APPLICATIONS: Infrared detection systems are predicted to be used in numerous civilian and medical markets, including surveillance, pollution monitoring, thermography etc. The durability and manufacturing simplicity of antireflction surfaces brought about by this program would result in improved cost-effectiveness and efficiency of existing and future infrared detectors.

REFERENCES:
1. Wilson and Hutley, The optical properties of the moth eye antireflection surfaces, Optica Acta, Vol 29, No. 7, 1003, (1983).
2. Yeh and Sari, Optical properties of stratified media with exponentially graded index of refraction, Appl. Optics, Vol. 22, No. 24 (1983).

AF99-175 TITLE: Ultra High Performance Soft Magnetic Materials for High Temperature Turbine Applications

TECHNOLOGY AREA: Materials, Processes and Structures

OBJECTIVE: Develop high performance soft magnet materials for use in aircraft integral power units and starter/generators.

DESCRIPTION: The performance and reliability of future aircraft can be greatly enhanced by the use of integral starter/generators (ISGs) and power units (IPUs). These devices can rotate at speeds up to 60000 rpm, creating hoop stresses of approximately 80ksi. Also, the temperature can rise to 550oC. A soft magnet material is needed to withstand these stresses and temperatures while experiencing less than 1% creep over 5000 hours and minimizing electrical losses. The best available FeCo materials available have good strength and magnetic performance but unacceptable creep performance at the operating temperature of these devices. Although silicon steels have good mechanical performance, they do not have the desired magnetic performance at elevated temperatures. The FeCo materials have the best available magnetic properties. Proposals should address manufacturing or compositional methods for improving the performance of these materials at elevated temperatures. Proposals may also address other materials capable of providing magnetic performance comparable to FeCo while achieving the mechanical and electrical loss goals.

PHASE I: Develop and demonstrate a material (alloy, composite, matrix, ceramic, etc.) capable of sustained high mechanical and magnetic and electrical performance even at elevated temperatures. This includes developing ceramic coatings to minimize core loss and exploring bonding laminates to form monolithic rotors.

PHASE II: Further optimize the performance of these materials and coatings as well as their manufacture. Additionally, a monolithic type rotor with high strength, low creep and high magnetic performance may be developed.

PHASE III DUAL USE APPLICATIONS: Improved high temperature capable magnetic materials have a significant potential for dual use in commercial applications of IPUs. The benefit of the More Electric Aircraft concept to commercial aircraft will be very significant and parallel those for Air Force applications. Additional applications can be found in alternative fuel vehicles and magnetic bearings for use in industry and power generation facilities.

REFERENCES:

(1) "More Electric Aircraft Integrated Power Unit Designed for Dual-Use", R. M. (Fred) Klaass and Dr. Buryl McFadden, SAE Paper No. 941159, Society of Aerospace Engineers, 1994.

(2) "The Integral Starter/Generator Development Progress", E. Richter, R. E. Anderson, and C. Severt, SAE Paper No. 920967, Society of Aerospace Engineers,1992.

KEYWORDS: permanent magnet materials, soft magnetic materials, rare earth magnets, iron-cobalt alloys, magnetic bearings, auxiliary electrical power

AF99-177 TITLE: Semiconductor Alloys for Mid-Infrared Applications

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop binary, ternary or quarternary semiconductor alloys in bulk form having band-gap in the 0.2 to 0.45 eV range.

DESCRIPTION: Ternary or quarternary alloys of In | Ga | Al | Sb or As can provide materials having band gap energies that can be selected by choice of the alloy composition. Such materials have been grown with the bandgap energy in the 1 | 1.5 eV range in both bulk and thin film form. For mid-wave infrared applications, it is desirable to obtain bulk material having bandgap in the 0.2 to 0.45 eV range. Binary alloys such as Te | Se with appropriate alloy composition would also provide material with appropriate band-gap. Proposals are solicited to develop such materials having good optical and surface properties along with low free carrier, impurity or defect concentration that can be fabricated into disks that are approximately 2.5 cm in diameter and 2 | 3 mm in thickness. PHASE I: During this phase the offeror will demonstrate the feasibility of the materials and the practicality of the process to develop them, to give a proof of principle and identify those materials/process issues which must be addressed during Phase II of the program.

PHASE II:Optimize the materials and/or processes to achieve performance or capabilities not currently available. Design, fabricate and characterize a test article based on the developed materials or process which demonstrates an advance in the state-of-the-art.

PHASE III DUAL USE APPLICATIONS: Alloy materials developed in bulk single crystalline form has the potential to provide materials with continuously variable lattice parameters between binary compounds and can serve as substrates for layers of various III-V or II-VI materials used extensively for manufacture of laser diodes and detectors for a broad range of commercial applications.

KEYWORDS: alloy, Ternary, quaternary, semiconductor, In-Ga-A1-Sb or As

AF99-178 TITLE: Switchable Microlenses for MEMS Applications

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop liquid crystal microlenses for switchable optics applications based on liquid crystal display technologies.

DESCRIPTION: Liquid crystals are used in flat and curved displays and are switchable as in, "Smart Windows", applications. These applications include space, aircraft communications and sensor systems. Microlenses are presently being used in many of these applications along with commercial large area display units. Many new uses of microlenses can be envisioned if the microlenses are switchable, i.e., the lenses appear upon command, otherwise the array containing them is transparent. This will provide an avenue to increase the light intensity on predetermined subunits composing a neighboring film array. , e.g., non-linear optical material devices. Non-linear and linear optical devices (e.g., rejection filters, graded optical limiters, rugate filters, and dielectric stacks) may be examined as part of a processing and materials effort to evaluate and demonstrate enhanced material performance.

PHASE I: During this phase the offeror will demonstrate the fabrication feasibility of liquid crystal microlenses, both standard and refractive. Refractive microlense fabrication could entail a major study in phase decomposition kinetics of applicable polymer dispersed liquid crystal systems.

PHASE II:During this phase of the program the offeror will optimize the switchable liquid crystal microlense array processing technique. The offeror will design, fabricate, and characterize a test article based on the developed technology in Phase I. The test article should demonstrate enhanced optical properties (e.g., optical limiting, linear or non-linear absorption, linear or non-linear refraction, etc.) over those devices presently used in the application area.

PHASE III DUAL USE APPLICATIONS: Microlenses technology is principally used in the commercial display sector, but if switchable (on/off, but always transparent), many military applications will benefit.

KEYWORDS: PDLC, Displays, Microlenses, Liquid crystals, Optical limiters, Non-linear absorption, Non-linear optical materials

AF99-179 TITLE: Munition Modeling and Technology Integration Research

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Assess weapon lethality, effectiveness, and utility; evaluate expected weapon performance; develop concepts for munition integration.

DESCRIPTION: New and innovative concepts in the area of air delivered conventional munitions are sought. The Assessment and Demonstrations Division of the Air Force Research Laboratory Munitions Directorate conducts research and directs exploratory development of advanced munition integration concepts. Munition integration areas under consideration include highly agile air-to-air missiles, air-to-surface munitions (unitary, penetrator, and dispensers), submunitions, and projectiles. Technology areas under consideration include aerodynamic shaping, advanced structural/material design application, innovative control surface stowage and deployment for compressed carriage, dispense and interface technologies (especially multiple carriage and dispense of small munitions), innovative flight controls and maneuver techniques (i.e., reaction controls, micro-adaptive control, etc.), and terradynamic control. Munitions integration with unmanned combat air vehicles is a key technology area. Interest areas also include hypersonic airframes, time-critical target defeat, bomb damage identification and bomb damage assessment, and non-lethal target defeat. Modeling and simulation tools of interest include high-fidelity physics based codes for warhead design and penetration analysis, engineering level tools for weapon/target interaction analysis, and improvements for theater level modeling of many-on-many combat. Also sought are models which enable prediction of the functional relationship of fire and/or blast effects on fixed structures as related to type of source explosive and models to optimize capability for evaluating dispersion of chemical/biological neutralization agents in a high-temperature, high-pressure environment.

PHASE I: Determine the technological or scientific merit and feasibility of the innovative concept. The merit and feasibility should be clearly demonstrated during this phase. A technical evaluation of the concept or methodology, a demonstration of proof of principal, or a description of a technical approach, alternative approaches, and associated risk factors may be appropriate.

PHASE II:Produce a well-defined deliverable prototype or munition-related simulation capability.

PHASE III DUAL USE APPLICATIONS: The military end products or processes resulting from this topic will be used to develop advanced munition airframes. Each proposal submitted under this general topic should have an associated dual-use commercial application of the planned technology. The commercial application should be formulated during Phase I. Phase II will require a complete commercialization plan. Innovative flight vehicle technologies could improve air vehicle performance, as would air foil products, i.e., wind turbines, turbomachinery, etc. Simulations of effects would reduce test costs and provide greater capability for safety officials and insurance underwriters to assess associated hazards. Improved simulation models using advanced analytical methodologies would be of value to a wide variety of commercial activities requiring analysis of the effectiveness of operations or product quality or performance. These developments could benefit commercial building demolition, safety-related assessments, auto safety research, explosives research, mining, drilling, and a wide range of product analysis and evaluation activities.

KEYWORDS: weapon, airframe, munition, assessment, simulation, demonstration

AF99-180 TITLE: Ordanance Research

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Identify, develop, and demonstrate commercial components having application to air deliverable munitions.

DESCRIPTION: New and innovative ideas/concepts are needed in the area of air delivered, non-nuclear munitions that have a dual use/commercialization potential. Military products include bombs; penetrators; submunitions; warheads; projectiles; fuzes (including safe and arm devices); explosives/energetic materials; time delayed, self-degrading explosives; genetic engineering of molecular explosives; polymer binders for shock survivable explosives; fiber optics; solid state inertial components; exterior ballistics; test technology; modeling and simulation resources and techniques; and conventional weapon environmental demilitarization and disposal techniques. Examples of desired research are target detection sensors for deeply buried targets; warhead initiation; self-forging fragment warheads; shaped charges; reactive fragment warheads; hard-target weapon/penetration technology; near field backscatter modeling for 60 to 300 GHZ detection devices; energetic materials; and low velocity deep earth penetrators. Concepts and methodologies for defeating and neutralizing chemical and biological agents during production, storage, and employment in weapons of mass destruction are desired. Technologies for denying enemy access to weapons of mass destruction are also of interest. Rapid solid-state reaction, combustion and detonation process models for metallic particle systems are of interest. These models should include energy extraction rate, theoretical descriptions of initiation, and kinetics of reaction. Process models shared also account for the physical processes unique to metallic particle energetic systems. Metallic particle sizes of interest are 10-100 nanometers. Models developed should provide insight into the impact of parameterization of particle size, surface area, and heat conduction rate as related to initiation and reaction behavior.

PHASE I: Determine the technological or scientific merit and feasibility of the concept.

PHASE II:Provide a deliverable product or process.

PHASE III DUAL USE APPLICATIONS: A wide range of commercial products could be produced from this research. Typical products include propellants, initiators, gas generators, high strength and high strain rate materials, low cost sensors/detectors, and environmentally compatible recycling processes for energetic materials. Each proposal submitted under this general topic should have an associated dual-use commercial application. Phase II will require a complete commercialization plan.

REFERENCES:
1. Progress in Astronautics and Aeronautics: An American Institution, by Martin Summerfield, Volume 21, Academic Press, 1963.
2. Dynamic Aspects of Detonation: Progress in Astronautics and Aeronautics, Volume 153, Book Publication of AIAA.

KEYWORDS: fuzes, warheads, explosives, simulation, nanoparticles, target detection, hard target defeat, safe arm fire devices, chemical neutralization

AF99-181 TITLE: Guidance Research

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop innovative concepts in guidance technologies for air deliverable autonomous munitions

DESCRIPTION: The Advanced Guidance Division of the Air Force Research Laboratory Munitions Directorate seeks new and innovative ideas/concepts in areas related to closed loop guidance, navigation and control of autonomous munitions. Topics of primary interest in navigation include very small, low cost inertial measurement units (IMUs), Global Positioning System (GPS) guidance, jam resistant GPS, and transfer alignment. Topics of interest in guidance technology include optimal guidance law development, target state estimators, and advanced adaptive autopilots. Topics of interest related to seekers include electrooptical, millimeter-wave, and radio-frequency seeker technology and the components and signal processing systems used in such seekers for autonomous guided munitions. This includes, but is not limited to, sources, detectors, polarization-sensing elements and systems, modulators (both single element and pixelated), pattern recognition and processing systems, and basic material and device development for accomplishing all of these; polarization-sensing elements and systems for studies of the utility of such systems for target characterization and discrimination; developing algorithms for use within autonomous target acquisition (ATA) applications; innovative signal and image processing algorithms used, for example, in synthetic aperture radar (SAR), millimeter-wave (MMW), imaging infrared (IIR), and laser radar (LADAR) needed to autonomously detect and recognize target signatures embedded in backgrounds; operations/functions associated with the ATA process involving noise elimination, detection, segmentation, feature extraction, classification (e.g., truck vs. tank), and identification (e.g., tank A vs.

tank B); utilization of Image Algebra in the development of non-proprietary ATA algorithms. Algorithms capable of processing/fusing multi-sensor data are of particular interest. Key research areas include signal and image processing, pattern recognition/classification, image understanding, artificial neural networks, fuzzy logic, superresolution, knowledge- and model-based vision, and data fusion. Topics of interest related to modeling and evaluation include synthetic target signature generation and scene projection technology for hardware-in-the-loop applications. Concepts must have a good dual use/commercialization potential.

PHASE I: During Phase I, the offeror shall determine the technological or scientific merit and the feasibility of the innovative concept.

PHASE II:The Phase II effort is expected to produce a well defined deliverable product or process.

PHASE III DUAL USE APPLICATIONS: Each proposal submitted under this general topic should have an associated dual-use commercial application of the planned technology. The commercial application should be formulated during Phase I. Phase II will require a complete commercialization plan.

KEYWORDS: LADAR, seekers, jam resistant GPS, artificial neural networks, guidance of autonomous munitions, algorithms for Autonomous Target Acquisition (ATA)

AF99-182 TITLE: Control of Large Micro-Eletro-Mechanical Systems (MEMS) Array

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop methods of controlling Hyper-Input/Hyper-Output (HIHO) systems of large arrays of MEMS.

DESCRIPTION: Investigate and demonstrate the feasibility of integrating hundreds/thousands of micro-fluidic actuators and sensors for flight control of a generic munition. The use of MEMS fluidic arrays in munitions applications has the potential to measure and control performance limiting physical phenomena such as flow separation, vortex dynamics, and turbulence. Better control of these phenomena through the use of Hyper-Input/Hyper-Out (HIHO) micro technology can lead to enhanced munition agility and performance. The mathematics required for the stabilization and control of large array structures has been previously developed, but these techniques cannot yet be directly applied for the munitions problem. The issue is to develop surface allocation strategies that produce forces and moments (which are by some measure optimal) which result in a controllable airframe. The dual problem of observability must also be addressed in the context of HIHO micro technology.

PHASE I: Proof-of-concept for this project should develop a design methodology and demonstrate the feasibility of implementing a HIHO control algorithm for a generic munition using MEMS fluidic actuators and sensors for control. The Phase I portion of this program should deliver a guided munition simulation incorporating the entire sensor/control scheme and design models used. A proposed air-frame should be recommended for implementation during the Phase II portion of the program.

PHASE II:Phase II would involve applying the design and testing performance on a hardware in the loop vehicle for the HIHO control algorithm and sensor fusion approaches.

PHASE III DUAL USE APPLICATIONS: Commercialization potential includes products which require control and coordination of arrays of micro sensors and actuators such as: sensors for automotive industry (pressure and acceleration), thermal inkjet print-heads, deformable mirrors, optical displays, and microfluidic devices for the medical industry.

KEYWORDS: MEMS, sensor fusion, fluidic arrays, micro-actuators, distributed control, micro pressure sensors, control surface allocation

AF99-183 TITLE: High Power Microelectronics Technology

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop high power microelectronic devices having both military and commercial application.

DESCRIPTION: Recent advances in the microelectronics industry have resulted in technologies which allow the use of smaller devices to perform certain electronic functions. In particular, advances have been made in both energy storage and power switching which allows for more performance per unit volume. Advances in the high energy density capacitor industry have resulted in increased energy storage in smaller packaged units. The goal of any effort in energy storage is to fabricate a low-cost capacitor with a minimum capacitance of 10-20 millifaraed, a voltage stability of 10 - 28 volts DC and an equivalent series resistance of 200 milliohms or less at room temperature. Power switching has evolved to a point where fast switching and high breakdown voltages are simultaneously achieved in micro sized devices. The focus of any effort in power switching is to develop microelectronic high power devices that have very short function delay (less than 50 nanoseconds) and are capable of reliable operation with a hold off voltage of 2 kilovolt and a large off-state resistance of more than 100 megohm. The focus of these efforts is to develop and fabricate commercially viable technologies that have military applications.

PHASE I: Phase I of this project should focus on the materials employed for these applications and the fabrication of these devices. For high energy density storage devices, an investigation could focus on the use of commercially available electrodes and electrolytes and alternative materials for the electrode. For high power switching applications, an investigation of the feasibility of modifying existing power semiconductor devices to meet the specific needs of military electronic fuzing could be conducted. The design of a prototype device(s) should be available by the end of Phase I.

PHASE II: Phase II should focus on the fabrication of devices with an emphasis on alternative materials and increased power density devices. A certain number of device(s) should be delivered for evaluation as a part of Phase II.

PHASE III DUAL USE APPLICATIONS: This area of research is unlimited in its use in both commercial and military markets. Any advances in this technology could be utilized by the cellular communications industry for longer battery life and a higher amplitude signal. In addition, applications in high power inverters for high voltage conversion of direct current to alternating current that can be transformed for general use and power microwave communication systems can also be realized. This technology would also be viable for commercial markets currently using similar technology.

REFERENCES:

1. W.F. Mullin, ABC's of Capacitors, Howard W. Sams, Inc., Indianapolis, IN, 1978

2. J. Vitins, J. L. Steiner, and J. A. Welleman, "High Power Semiconductors for Pulsed Switching," Seventh IEEE Pulse Power Conference (1989) pp 352-357.

KEYWORDS: electrolytes, firing systems, energy storage, aluminum hybrid, high power semiconductors, high speed solid state relay, capacitors (high surface area), microelectronic high power devices

AF99-184 TITLE: Electrical Disablement of Large Structures and Vehicles

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop electrical energy transport and/or conversion mechanisms for conventional warheads target neutralization.

DESCRIPTION: Advances in Explosive Flux Compression Generators (EFCG) and pulsed electrical power generation have opened the door to new opportunities in nonlethal incapacitation for law enforcement agencies and less than lethal conventional munitions for disablement of structures and vehicles. Compact, high-energy electrical sources can be integrated into weapon systems as part of an alternate lethal mechanism or as energy storage devices for a non-traditional explosive techniques. The use of an electrical warhead system could result in smaller munitions delivering equivalent energy to targets while, at the same time, increasing their effectiveness in neutralizing important assets. Implementation of an electrical warhead may be done in a variety of ways such as directly coupling an electrical pulse to a target using methods such as pulse coupling, explosively deployed conductors, high energy lasers, shaped-charge jets (2), conductive fluids, or conductive gases. Alternatively, certain classes of energetic materials might benefit from pulsed electrical power in terms of enhancing target interactions or reducing collateral damage. Presently, the Air Force Research Laboratory Munitions Directorate is investigating air-launched munitions to defeat a wide variety of electronically significant targets in both lethal and non-lethal modes. The goal of this topic is to encourage ideas that use non-radiative electrical energy to improve target neutralization capabilities and to increase the effectiveness of conventional explosive munitions.

PHASE I:Efforts should be concerned with formulation of system concepts based on lethal and nonlethal effects. The formulation of concepts should be followed by verification of the order of magnitude of the proposed effect. This verification should be accomplished through analysis or experimentation. Effects of interest are those which inflict wide spread damage, disruption and denial of electronic equipment, computers, communication systems, and power utility systems.

PHASE II:Concentrate on well designed experiment to demonstrate various components of the proposed target defeat system conceived during Phase I. Fabrication of proposed system components and execution of the scaled or full-scale experiments will be conducted during Phase II to verify that the alternate lethal mechanism is feasible and worthy of Phase III consideration.

PHASE III DUAL USE APPLICATIONS: Component technology developed in this field will benefit the commercial well drilling and mining community in the development of compact high energy power sources, pipe perforation systems, compact multi-point initiators, firesets immune to high magnetic fields, advanced high energy explosives, bore-hole to bore-hole tomography and compact shaped-charge jets. In addition, law enforcement would benefit greatly by technologies to immobilize vehicles or deny access to facilities without lethal effects to inhabitants. Electrically triggered non-explosive materials can significantly increase the safety and reduce costs for all industries that presently use conventional explosives. Additional commercialization potential is realized with active lightning protection for high value commercial and government assets, wireless transmission of electrical power, artificial triggering of lightning and police/security force non-lethal vehicle stopping devices. The Air Force Research Laboratory Munitions Directorate may also separately fund a follow-on Phase III effort for actual integration and testing of new lethal mechanisms in appropriate weapon systems.

REFERENCES: "FY98 Technology Area Plan (TAP)", Air Force Research Laboratory Munitions Directorate, Eglin AFB, FL, 32542-6810, (850) 882-0266/9643.

KEYWORDS: warheads, pulsed power, electromagnetic, enhanced lethality, conventional weapons, nonlethal disablement, explosive pulsed power, reduced collateral damage, electrical explosive enhancement

AF99-185 TITLE: Micro-Electro-Mechanical Systems (MEMS) Technology for System Safety and Control

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Demonstrate low voltage, low energy components compatible with Micro Electromechanical Systems (MEMS) for safing systems.

DESCRIPTION: Recent advances in MEMS technology have resulted in the demonstration of environmentally and electrically activated devices applicable to safe, arm, and fire (SAF) systems that include electromechanical decoders, rotors and sliders. These devices could potentially become significant in reducing the size and cost of safety systems in conventional weapons. There are, however, significant "missing links" in the technology that would prevent it from reaching its full potential. One link is the technology required to achieve low energy (less than 0.1 milijoule), low voltage (5-volt), initiation mechanisms (detonators) that are capable of being interrupted by movements (of 20 mils) with a MEMS SAF device. Current non-MEMS devices require 250-mil movement to inhibit initiation. The goal of this effort is miniaturization of low energy, electrically activated devices that would allow for the use of MEMS SAF devices. It is anticipated that new and unique approaches to the electrical release of chemical energy and the efficient coupling of the chemical energy to some type of mechanical energy (i.e. flyer) and prime movers will be required.

PHASE I:Investigate the feasibility of the proposed concept. This investigation should include energy transfer mechanisms, detonation of a high-density secondary explosive at a point past the anticipated barrier, and the capability of preventing the secondary explosive functioning by MEMS scale devices

PHASE II:Focus on the design and fabrication of components of the SAF system. The final demonstrations should include actual firing of output charges and determination of the effectiveness of the barrier intercouple or other detonation prevention mechanism. A quantity of items will also be delivered to the government for evaluation at the end of Phase II.

PHASE III DUAL USE APPLICATIONS: The evaluation of a systems safing device in MEMS scale which is compatible with high volume production can benefit the electro-explosive and computer control systems industry. The employment of MEMS with electro-explosive devices could lead to new and unique applications in many emergency areas such as the "Jaws of Life."

REFERENCES: See website: http://www.mdl.sandia.gov/micromachine/

KEYWORDS: detonators, initiators, micromachines, micro electromechanical systems

AF99-186 TITLE: Wireless Data Transmission Through Various Media

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop and demonstrate a miniature, high shock resistant data link for transmitting information in an underground environment.

DESCRIPTION: The ability to transmit data from an underground location to a relay device on the surface is desired. Applications such as shallow mining, urban below street data transmission, and real-time transmission of data from a penetrating weapon including post penetration transmission, are sought. The Air Force is interested in transmitting smart fuze data from penetrating weapons to provide battle damage information. This information must be transmitted from the buried weapon through layers of soil, concrete and other media such that it arrives at a receiver located at ground level or is available to aircraft in the area. This program will examine methods for collecting and relaying information from a penetrating weapon to a receiver. Systems to transmit data should be proposed by the respondent. As an option, the respondent may propose new systems for collecting and relaying the data required to assess target damage. Technology such as microelectromechanical systems (MEMS) maybe considered for the collection and transmission of real time bomb damage information in the post-event environment if their survivability can be verified.

PHASE I:Phase I of this project will identify a method of obtaining battle damage information (BDI) from weapon born sensors (WBS). The WBS will be contained or attached to an air delivered penetrating weapon. This project will develop a WBS concept and analytically determine the feasibility of data transmission through dense target media. The feasibility of packaging the concept in a penetrating weapon will be determined. The critical post-event information to be collected and transmitted will be identified (e.g. ambient pressure and temperature, ambient gas content and sound video).

PHASE II:Phase II will fabricate and demonstrate the WBS system or data transmission system for a WBS. A shock hardened transmitter system will be built and tested on shock machines and in gun launches against hard targets. Demonstrations will be conducted to insure that data can be transmitted through various media. Real time battle damage assessment (or bomb damage information) sensors must be designed and fabricated based on the requirements defined in Phase I. These devices must be capable of withstanding the munition penetration/explosion events.

PHASE III DUAL USE APPLICATIONS: This project will provide useful wireless transmission research to both military and industry. Advances will enable development of wireless underground communications for shallow mining, urban below street access tunnels and emergency communications for subways. Ruggedized micro sensing devices may also have applications in industry machinery to monitor and regulate manufacturing processes.

REFERENCES:

1. H. Heys, "Digital Communications - Encoding", 3rd edition (1994)
2. Internet article, "Data Encoding Modulation", http://192.107.38.102/cpe471 (1997)
3. Internet article, "Data Encoding", http://www.csm.ohiou.edu (1997)

KEYWORDS: penetration fuzing, hard target weapons, weapon borne sensor, battle damage information, shock-hardened transmitter, dense media data transmission

AF99-187 TITLE: Integrated Guidance - Exploitation of Body-Shading for Anti-Jam GPS

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Demonstrate an integrated guidance algorithm to exploit body-shading and antenna gain patterns for anti-jam GPS.

DESCRIPTION: Provide a technical basis from which an integrated guidance navigation design approach can be leveraged for precision munitions. The design approach has application to many functional areas: guidance fuzing integration for mass focused ordnance technology, guidance control integration for reduced radar cross section of cruise missiles, and anti-jam GPS capability based on body shading. The specific application of integrated guidance for this program is to investigate the feasibility and demonstrate an anti-jam GPS capability based on exploitation of body shading. It is currently common to select a GPS receiver antenna and place it on a guided munition air-frame in such a way as to minimize acquisition time and the effects of ground based jammers. Basically the antenna system is placed in such a way as to maximize the GPS signal received during a typical mission scenario. It is possible to exploit this same concept during the guidance maneuvers of the vehicle as well. Since the GPS satellites and jammers are typically not co-located, the air-frame can be steered so that the antenna gain pattern is pointed where satellites are located. This concept can also be used to maximize GPS accuracy by optimizing antenna direction relative to the satellite constellation. Current guidance algorithms do not directly attempt to actively exploit the above concepts. In the past, guidance algorithms for munitions have focused on minimizing miss distance or maximizing kinetic energy at impact; the increasing reliance on GPS for navigation suggests these new criteria for optimal guidance involving the minimization of the jamming energy received at the antenna. This method of anti-jam GPS is significantly different than the signal processing techniques which are commonly employed.

PHASE I: The first portion of this project will be an investigation that quantifies the benefit of using the effects of body-shading to provide some level of anti-jam GPS capability. The concept is to develop a full envelope guidance algorithm that satisfies both initial and final conditions for a ground fixed target and exploits body-shading. The Phase I portion of this program should deliver a guided munition simulation incorporating the guidance algorithm. The Phase I effort should investigate the sensing requirements (what sort of knowledge ((accuracy)) is required on the location of the jammers) for this sort of anti-jam technique.

PHASE II: The second phase of this project should apply the guidance algorithm developed under Phase I to a representative piece of hardware. Selection of GPS antenna/receiver and experimental identification of the antenna gain as a function of vehicle orientation will be required. A proposed air-frame would be the diamond-back Miniature Munition Technology Demonstration (MMTD), although the Phase I effort may identify a better candidate. These experimental results would then be used for detailed simulation of the concept munition. Depending on cost, it would be desirable to incorporate signal processing techniques providing anti-jam capability for an integrated anti-jam solution.

PHASE III DUAL USE APPLICATIONS: The exploitation of anti-jam guidance algorithms based on exploitation of body shading would have direct application to the next MMTD system (scheduled to demonstrate an anti-jam capability.) In addition to the military application, the formulation of guidance algorithms that minimize non-standard cost functions has application in the area of robotics. Robots that search inhospitable regions (radioactive environments for example) would be able to use the concepts developed here directly. Such environments often have hazards that mathematically can be represented much the same way as GPS jammers.

REFERENCES: NAIC-ID(RS)T-0067-96, "The United States Military Begins to Recognize the Susceptibility of the Global Positioning System to Jamming," Feb 1996. ADA 304637

KEYWORDS: GPS, control, guidance, anti-Jam, navigation, antenna Gain, body-Shading

AF99-188 TITLE: Biomimetic Applications for Autonomous Guided Munitions

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Leverage understanding of insect neurobiology to develop novel autonomous munition closed loop guidance systems.

DESCRIPTION: Life forms as well as smart munitions collect visual, inertial, and kinesthetic information from the environment, process it, and make decisions. Decisions may be object detection, identification, a change of position for better tracking or acquisition, or a navigation or guidance decision. Much research aimed at understanding natural paradigms has been previously accomplished to address biomedical objectives. There have been previous successes from exploiting natural paradigms, such as neural networks, genetic algorithms, and evolutionary computation technologies. Specific sensory applications include vision chips performing outer retinal processing in the analog domain. Other hardware demonstrations have modeled auditory, olfactory, and cortical processing functions. Models of insect guidance and navigation sensors and control functions and mechanics of movement could be used for closed loop guidance, navigation and control functions. It is desired to leverage the knowledge of structure and functionality of these and other natural systems to guide the development of innovative autonomous guided munition system concepts. Any innovative integration of previously demonstrated biomimetic guidance components will be given favorable consideration. While leveraging biomedical understanding, this SBIR project should also leverage commercially available hardware and software technology to ensure maximum sensor capability at affordable production costs.

PHASE I: The proposal should identify candidate biological paradigms and establish a clear understanding of how they relate to the function of an autonomous munition guidance system. The proposal should identify candidate concepts to be explored and demonstrate familiarity with applicable commercial components. During Phase I a hardware prototype system or its significant components should be developed and demonstrated as a proof of concept. Simulations may be substituted if hardware implementation is either trivial or not feasible. The design of a Phase II system should be presented at the end of Phase I.

PHASE II:Develop autonomous components demonstrated and/or designed in Phase I. Demonstrations should be designed so that implementations and commercial system applications are straightforward.

PHASE III DUAL USE APPLICATIONS: The military end product of this anticipated effort will be a seeker prototype leveraging the understanding of biological information processing structures and functionality. This technology could be used commercially in real-time imaging applications, machine vision applications, robotics, and general signal transmission, processing and storage applications.

REFERENCES:
1. N. J. Strausfeld, Atlas of an Insect Brain, Springer-Verlag, 1976
2. D. G. Stavenga, R. C. Hardie (eds.), Facets of Vision, Springer-Verlag, 1989
3. M. Burrows, The Neurobiology of an Insect Brain, Oxford University Press, 1996
4. Chapman, The Insects: Structure and Function, 3rd edition, Harvard University Press

KEYWORDS: biomimetics, iInsect flight control, distributed feedback control

AF99-189 TITLE: Multimode/Multispectral Seeker Autonomous Target Acquisition (ATA) Algorithms

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Design, develop, and demonstrate state-of-the-art ATA algorithm approaches applicable to multimode/multispectral seekers.

DESCRIPTION: The precision guidance of autonomous lock-on-after-launch weapons to high value targets, both fixed and mobile, in high clutter backgrounds under adverse weather conditions and low light conditions, represents one of the outstanding challenges facing the tactical weapons development community today. The application of multimode/multispectral seekers to the smart weapons offers numerous performance benefits over traditional single-sensor implementations. Every seeker has its own peculiar set of advantages and disadvantages when implemented on smart munitions. Frequently, however, individual advantages complement each other such that disadvantages are overcome. The object, then, is to fuse these advantages in an optimal manner. In order to exploit sensor fusion, scene and target registrations are required among the seeker channels. The combining of data or information requires the registration algorithm to account for measurement uncertainty in characteristics shared by the seeker channels as well as in characteristics unique to each seeker channel. The incompatibility of resolution, translation, and registration characteristics of different sensors must be resolved before applying ATA algorithms. Development, evaluation and delivery of state-of-the-art hybrid decision making multimode/multispectral seeker (laser radar and imaging millimeter wave (MMW) channels) ATA algorithms constitute the main thrust of this effort. The proposed concepts and their development should include the design criteria for both image registration and ATA algorithms. The ATA algorithm development should include target detection, segmentation, classification, and identification functions. Conventional, unconventional , and hybrid approaches should be investigated. The assessment of strengths and weaknesses of each approach should be performed.

PHASE I: Assessment of image registration and the hybrid multimode/multispectral seeker ATA algorithms applicable to laser radar and active or passive imaging seeker channels should be performed. A conceptual design including possible conventional, unconventional and hybrid approaches (such as statistical pattern recognition, model-based, artificial neural networks, fuzzy logic, and/or wavelets) should be developed. The inherently low lateral resolution of MMW seekers should be mitigated through use of superresolution algorithms or other innovative means. The sponsor can, if desired, provide an acceptable superresolution algorithm for preprocessing MMW image data. The detailed design of proposed image registration and the hybrid multimode/multispectral seeker ATA algorithms applicable to laser radar with active or passive imaging MMW sensors shall be developed.

PHASE II: The software development based on the conceptual study and design of Phase I will be constructed and demonstrated against measured and simulated data. The data will be provided by the sponsor. The software will be developed on a UNIX hardware platform compatible with the sponsor hardware. The software development should be conducted using a modular software engineering approach. The software will be developed under the Khoros environment and will be fully compatible with the Modular Algorithm Concepts and Evaluation Tool (MACET) software package. MACET software will be provided by the sponsor.

PHASE III DUAL USE APPLICATIONS: Collision avoidance for air and ground transportation, medical imaging, robotics or machine vision, quality control for production systems, commercial surveillance systems, image-recognition systems, and agriculture survey and assessment are all possible commercial applications.

REFERENCES:

1. Qinfen Zheng and Rama Chellappa, " A Computational Vision Approach to Image registration," IEEE transitions on Image Processing, Vol. 2, No. 3, July 1993, pp. 311-326

2. Edward Waltz and James Llinas, " Multisensor Data Fusion," Artech House 1990

3. Lawrence W. Nelson and Ellis Boudreaux, "Raw Data Fusion Using the Generalized Likelihood Ratio," Proceeding of the 7th National Symposium on Sensor Fusion, Vol. 1, March 1994, pp. 251-277

4. Guner Robinson and Omar Aboutalib, "Trade-off Analysis of Multisensor Fusion Levels," Proceedings of the 2nd National Symposium on Sensor Fusion, Vol. 2, March 1989, pp. 21-34

5. J. M. Gillberg, M. Stenoien, and V. Landwehr, "MMW/IR/LADAR Sensor Fusion for Automatic Target Recognition," Proceedings of the 2nd National Symposium on Sensor Fusion, Vol. 2, March 1989, pp. 175-177

KEYWORDS: data fusion, sensor fusion, superresolution, image processing, dual-mode seeker, image registration, image understanding, multispectral sensors, autonomous target acquisition algorithms, automatic target recognition (ATR) algorithms

AF99-190 TITLE: Concrete Building Materials Microstructural Damage Quantification

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop experimental analysis tools for quantification of microcracking and void collapse distributions in damaged concrete.

DESCRIPTION: Damage on a microstructural level in concrete has been a difficult problem to detect. Many studies have been done in the civil engineering community, particularly on road and bridge applications, to identify microstructural damage and determine its influence on structural integrity. Studies in penetration mechanics also show that the penetrability of concrete is directly influenced by microstructural parameters. There have been various breakthroughs in techniques for visualizing microcracking and void distributions in concrete. Correlating microstructural characteristics to their effect on the properties of concrete is a significant technical challenge. The primary focus of this effort is to develop or exploit experimental and visualization techniques for the quantification of microcracking and void collapse distributions in damaged concrete. Once developed, the use of these techniques to relate microstructural parameters to the effect on common material properties such as compressive strength, bulk modulus, and elastic moduli will be explored. The goal is to develop a low cost, experimentally based process to quantify microstructural damage in concrete. Once defined these techniques could then be automated using computer based analysis to quantify microstructural damage and predict influence on material properties.

PHASE I: Phase I of the investigation should concentrate on developing microstructural damage visualization and quantification techniques for concrete. This should include the ability to identify the quantity, distribution, and change of distribution, volume, and change of volume characteristics of microstructural cracks and voids. As a separate or combined effort, computer automated data reduction techniques of microstructural damage could be addressed using existing computer software or through the proposed development of new software.

PHASE II:This phase would focus on developing methods to correlate the observed microstructural damage parameters with their affect on material properties such as compressive strength, bulk modulus and elastic moduli. A separate or combined effort under this phase could also provide for the integration of microstructural damage analysis techniques developed under Phase I into a viable computer software package for automated data reduction.

PHASE III DUAL USE APPLICATIONS: This technology has a broad base of application for both the military and industry. Advances in the quantification of microstructural damage in concrete will have a profound impact on construction, maintenance, hardening, and defeat of concrete structures. Applications to commercial and government construction, maintenance, hardening, and defeat of concrete structures. Applications to commercial and government construction include structural and life cycle analysis for building, roads, bridges, dams, waste and radiation containment systems, hardened structures, and force protection structures. Advances in this area could easily be adapted to fracture in other brittle materials or exploited to enhanced ballistic penetration of these materials. This technology would be invaluable in analyzing earthquake or explosively damage structures.

REFERENCES:
1. Krajcinovis, D., "Continuum Damage Mechanics," Applied Mechanics Reviews, Vol. 37, No. 1, pp. 1-6, 1984.
Malvern, L.E., Jenkins, D.A., and DeHoff, R.T., "Rate and Confinement Effects on Cracking and Failure in Uniaxial Compression of Concrete," Final Report No. AFOSR TR-93-0071, Contract No. AFOSR-90-0074, 15 Nov 89 to 29 Jun 92.
2. Tu, H. "Quantitative Characterization of Crack Geometry in Concrete Compressed Uniaxially at High Strain Rate," M.S. Thesis, University of Florida, 1991.
3. Taylor, L.M., Chen, E.P., and Kuszmaul, J.S., "Microcrack-Induced Damage Accumulation in Brittle Rock under Dynamic Loading," Computer Methods in Applied Mechanics and Engineering, Vol. 55, pp. 301-320, 1986.
4. Underwood, E.E., "Quantitative Microscopy." McGraw-Hill Book Co., Inc., New York, 1968.

KEYWORDS: voids, grout, damage, impact, mortar, cements, cracking, fracture, Concrete, imagining, penetration, petrography, bulk modulus, microanalysis, microcracking, image analysis, microstructure, brittle fracture, geologic materials, concrete structures, compressive strength, modulus of elasticity, scanning electron microscopy

AF99-191 TITLE: Non-Linear Optical Techniques for Imaging LADAR Transceivers

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop a LADAR transceiver that implements non-linear optical techniques in novel ways to improve performance.

DESCRIPTION: Past research into imaging Laser Radar (LADAR) transceivers has resulted in systems that use non-linear optical techniques to enhance laser output (output energy or wave length conversion). However, non-linear optical techniques have not generally been used in the receive path where the return pulse is simply focused onto an appropriate detector, and gain in the detector amplifies the signal produced. We propose to investigate the use of non-linear optical techniques in novel ways to explore their effects on system performance. For example, by using an optical amplifier in the return path, the intensity of the return pulse can be modulated before it is focused onto a detector. A particular advantage of such a design would be the ability to optically modulate the effective gain of the receiver, allowing for the exploration of various LADAR detection techniques (e.g. range-gating, coherent detection of intensity modulated pulses, etc.) A range-gating implementation would be useful in improving the performance of LADAR in weather. Another example is to use non-linear optical devices to convert the return pulse to a wavelength region where better detectors are available, thus improving the signal-to-noise ratio of the electronic signal produced. Such a device might allow the use of eyesafe (> 1.5 micron) laser outputs, while leveraging the excellent performance characteristics of silicon detectors (which have a cutoff around 1 micron). There are many possibilities for transceiver designs that utilize various non-linear devices to achieve novel imaging LADAR approaches. Desirable characteristics include compact designs appropriate for non-laboratory environments, eyesafe operation, multiple wavelength operation, and wavelength tunable output. Proposals need not investigate every component of a system concept (e.g. electronics, scanner, etc.), but should address how the transceiver design could be implemented in a complete LADAR system. LADAR system concepts should be appropriate for at least laboratory breadboard use to ranges on the order of 1 km or greater.

PHASE I: Investigate the performance of the proposed transceiver through modeling, construction, and experimentation with critical elements of the proposed design. The investigation results would be incorporated into a detailed prototype transceiver design to be reported at the end of Phase I.

PHASE II:Involves the construction and delivery of a transceiver prototype based upon the design and components investigated in Phase I.

PHASE III DUAL USE APPLICATIONS: Advances in LADAR transceivers can result in new system capabilities appropriate for a variety of uses in the military and commercial sectors. Potential commercial uses include remote sensing applications for environmental monitoring, security systems, and vehicle proximity warning sensors. Potential military uses include munition seekers, airborne reconnaissance and surveillance, and targeting systems.

REFERENCES:

1. Fox, Clifton S. (ed.), "The Infrared & Electro-Optical Systems Handbook," Volume 6: "Active Electro-Optical Systems," SPIE Optical Engineering Press, Bellingham WA, 1993.

2. Jelalian, A., "Laser Radar Systems," Artech House, Boston, 1992.

3. "Electro-Optics Handbook," RCA Solid State Division, Lancaster PA, 1974.

4. Wolfe, W.L., Zissis, G.J., "The Infrared Handbook," Environmental Research Institute of Michigan, Ann Arbor, 1989.

5. Amnon Yariv & Pochi Yeh, "Optical Waves in Crystals: Propagation and Control of Laser Radiation," John Wiley & Sons, New York, 1984.

KEYWORDS: LADAR, laser radar, laser ranging, non-linear optics, optical amplifiers, wavelength conversion

AF99-192 TITLE: LADAR Scene Projection for Hardware-In-The-Loop Testing

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: A real-time method to optically stimulate a LADAR seeker during closed-loop testing.

DESCRIPTION: Currently hardware-in-the-loop testing of LADAR guided munitions is accomplished through digital scene injection. Polygon models of targets and backgrounds are used to generate pixelized range data that are appropriately formatted and sequenced for digital injection into the munition signal/image processor. In the immediate future the same LADAR data will be injected in the form of time delayed optical pulses into the detectors in the LADAR seeker by by-passing the seeker optics. These methods however represent a compromise in that the test facility assumes that it knows perfectly the seeker gimbal position and body attitude position in order to synthetically generate the correct data. In addition, the injected pulses are idealized and do not accurately represent the pulse shapes characteristic of laser returns from complex targets and backgrounds.

A method is desired to optically represent time-delayed laser returns to a seeker during closed-loop weapon testing. The weapon system will provide a timing reference in the form of either a laser pulse or an electronic signal and the scene projector will provide temporally accurate laser return pulses. At a minimum, a method is desired to directly inject accurate optical signals into sensor detectors. Ideally, the seeker would be free to look anywhere within the oversized field-of-view of a projector. Data describing the time-delays and reflected pulse shapes for all points within the field-of-view of the projector will be provided by a scene generation computer based on the relative distances between scene entities and the seeker. Relative time-delay accuracy for the projector pulses must be on the order of 0.5 nanoseconds.

PHASE I: Focus on defining a LADAR projection concept that can meet the above defined objectives. Leveraging commercial off-the-shelf hardware and software solutions to support this task must be considered. Concept accuracy, limitations, and system interface requirements should be estimated.

PHASE II:Develop and demonstrate a hardware prototype of the projection concept.

PHASE III DUAL USE APPLICATIONS: LADAR Scene Projector technology could be used to greatly reduce the risk in development of complex 3-dimensional imaging systems. This class of imagining system could be used for detailed surveillance and terrain mapping by police, investigative, and search and rescue agencies or for exploration of regions by unmanned vehicles. Adequate test of these complex systems will reduce development and deployment risks and enhance commercial viability.

REFERENCES:
1. L. Y. Byrd III, R. A. Thompson, Hardware-in-the-loop testing for the LOCAAS laser radar antimateriel munition, SPIE Proceedings - Technologies for Synthetic Environments: Hardware-in-the-Loop Testing, April 1996
2. E. M. Olsen, C. F. Coker, Real-time range generation for hardware-in-the-loop testing, SPIE Proceedings - Technologies for Synthetic Environments: Hardware-in-the-Loop Testing, April 1996

KEYWORDS: LADAR, laser radar, scene generation, scene projection, hardware-in-the-loop

AF99-193 TITLE: Fast Imaging Polarimetry

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop fast imaging polarimetry for detection of polarization signatures of targets and backgrounds.

DESCRIPTION: The Advanced Guidance Division of the Air Force Research Laboratory Munitions Directorate is interested in supporting the development of polarization sensitive imagers, investigating the underlying phenomenology, and characterizing polarization critical optical components. Polarization imaging holds promise for providing significant improvements in contrast in a number of target detection and discrimination applications. Polarization signatures arise from the preferential emission or reflection of light in the planes perpendicular and parallel to a target surface. Polarization signatures are dependent on the wavelength, the surface properties (index of refraction and surface roughness), external sources, and the geometry of the sensor, the surface, and the sources. In several experimental systems, significant contrast has been demonstrated that complements the conventionally imaged signature. However, these experimental systems frequently require long data acquisition times resulting in artifacts in the polarization signature due to changes in the scene. Additionally, calibration and investigation of systematic errors in these systems is difficult and robust calibration procedures have not been fully demonstrated. Proper calibration requires accurate laboratory instrumentation to characterize the full polarizing properties of the polarization critical optical components in the polarization imagers. Laboratory instrumentation is also required to better characterize target and background materials and understand the variation of polarization signatures with wavelength, geometry, and material property. The goal of the Munitions Directorate is to investigate novel imaging polarimeter concepts that measure some or all of the polarization parameters and address advanced seeker requirements for speed and sensitivity. In addition, this effort will consist of the investigation of the phenomenology that produces polarization signatures, development of calibration devices or procedures for polarizatin imaging systems, and development of instrumentation that characterizes the polarization properties of materials and critical optical components.

PHASE I: Investigate novel concepts for imaging polarimeters and design laboratory instrumentation for the characterization of polarization properties of materials and optical components.

PHASE II:Produce a prototype of the imaging polarimetric instrumentation and demonstrate the measurement capabilities in appropriate tests. Proper calibration procedures and any necessary calibration hardware should be developed and verified.

PHASE III DUAL USE APPLICATIONS: Multiple military applications include not only advanced seekers for autonomous guided munitions, but also mine detection, trip wire detection, and theater missile defense. A wide range of commercial applications can be projected including humanitarian de-mining, ice detection, machine vision, and display technology. The commercial application should be formulated during Phase I. Phase II will require a complete commercialization plan.

REFERENCES:
1. D. H. Goldstein, R. A. Chipman, and D. B. Chenault, "Infrared Spectropolarimetry," Optical Engineering, 28 (2), 120-125 (1989).
2. H. F. Anderson, "Infrared polarimetric sensor for missile weapon systems," RD-MG-968, Proceedings of the Workshop on Infrared and Millimeter Wave Polarimetry (1995)
3. T. J. Rogne, F. G. Smith, and J. E. Rice, "Passive Target Detection using Polarized Components of Infrared Signatures," Proc. SPIE 1317, Polarimetry: Radar, Infrared, Visible, Ultraviolet, and X-Ray, R. A. Chipman ed. 242-251 (1990).
4. C. Chun, D. L. Fleming, W. A. Harvery, E. J Torok and R. D. Juday, "Polarization sensitive thermal imaging sensor," RD-MG-96-8, Proceedings of the Workshop on Infrared and Millimeter Wave Polarimetry (1995).

5. D. H. Goldstein and D. B. Chenault, "Evaluation of a selection of commercial polarizers and retarders at visible and near infrared wavelengths," Proc of SPIE 3121 (1997).

KEYWORDS: retarders, polarizers, polarimetry, Stokes vector, Stokes parameters, imaging polarimeters, polarization elements, polarization signatures

AF99-194 TITLE: Visible Wavelength Scene Projection for Hardware-In-The-Loop Testing

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: A real-time method to optically stimulate a visible seeker during closed-loop testing

DESCRIPTION: Munition systems are being proposed that take advantage of signature characteristics of targets at visible wavelengths. A projection system is required for real-time representation of target images during hardware-in-the-loop testing. In hardware-in-the-loop tests a scene generation computer produces an image based on the relative position and orientation of the munition and the target. This digital information is then fed into a calibrated projection system for presentation to the munition sensor. Most recent development effort has been in the infrared wavebands. A visible projection concept is required that is flickerless, i.e., non-scanning, and has a large pixel format. Formats greater than or equal to 1024x1024 are required. Projector framerates greater than 100Hz are required. Other key parameters are uniformity, repeatability, dynamic range, and resolution.

PHASE I:The program should focus on defining a visible projection concept that can meet the above defined objectives. An initial concept demonstration is required. Leveraging commercial off-the-shelf hardware and software solutions to support this task must be considered. Concept accuracy, limitations, and system interface requirements should be estimated.

PHASE II:Develop and demonstrate a usable projection system.

PHASE III DUAL USE APPLICATIONS: This technology will allow for detailed hardware-in-the-loop test of many classes of complex vehicles that are controlled using visible sensor systems. These vehicles might include unmanned space vehicles executing docking maneuvers, or autonomous exploration and surveillance systems. The visible projector has the potential to enhance the state-of-the-art of movie projection systems for the entertainment industry by increasing dynamic range, intensity resolution, and framerate.

REFERENCES:
1. L. Y. Byrd III, R. A. Thompson, Hardware-in-the-loop testing for the LOCAAS laser radar antimateriel munition, SPIE Proceedings - Technologies for Synthetic Environments: Hardware-in-the-Loop Testing, April 1996
2. E. M. Olsen, C. F. Coker, Real-time range generation for hardware-in-the-loop testing, SPIE Proceedings - Technologies for Synthetic Environments: Hardware-in-the-Loop Testing, April 1996

KEYWORDS: scene generation, scene projection, hardware-in-the-loop

AF99-195 TITLE: Innovative Methods for Improving Strength and Fracture Toughness of Steel

TECHNOLOGY AREA: Materials, Processes, and Structures

OBJECTIVE: Develop innovative concepts and processes and materials for improving strength and fracture toughness of steels.

DESCRIPTION: New and innovative concepts, processes and materials are required in the area of air delivered non-nuclear munitions that will have a dual use and high commercialization potential. Current methods for improving strength and fracture toughness are generally limited to reduction of sulfur content and adding substantial concentrations of cobalt and nickel. As a result, significant improvements have been made for the required properties but they have driven the cost of steel up 6-10 times that of ordinary steel. Now that it is known that the higher performance can be obtained, concepts and processes must be developed that will drive the cost back down while maintaining the desired characteristics. Areas of research include improvements in quality control, functionally gradient materials, heat treatment, mechanical forming processes, microstructural gradient control, reduction of inclusions that cause embrittlement and development of inclusions that improve strength in concert with fracture toughness. The necessity for improvements is apparent as targets are further hardened, requirements for terradynamic steering are added and production costs continuing escalating. Military uses include bombs, penetrators, subminutions, warheads, projectiles, fuze assemblies, aircraft structures, etc. Commercialization uses include higher performance and lighter weight car and truck frames, commercial aircraft structural components, bridge structures, etc.

PHASE I: Investigate new and innovative concepts, processes and materials for improving strength and fracture toughness of steels. Develop methodology of the proposed processes and establish control parameters. Demonstrate procedures are generally applicable and yield expected results.

PHASE II: Develop and demonstrate that the proposed concepts, processes and materials are valid and that the results are approaching properties established for materials such as HP9-4-20 up to AF-1410. Develop mechanical properties data base for supporting hydrocode development and produce one-quarter prototype penetrators.

PHASE III DUAL USE APPLICATIONS: This exploratory development program has extremely high utility for both the military as well as the commercial sector. Military tactical program objectives of increased penetration, terradynamic steering and reduced costs will benefit from the improved mechanical properties. Military aircraft developers will have greater latitude in design of weapon bays and deployment options by utilizing smaller, more efficient weapons. Commercial steel users such as aircraft manufactures, automotive producers and bridge contractors will have new materials available for new design that are more efficient and cost effective.

REFERENCES:

1. Speich, G. R. and Spitzig, W. A., "Effect of Volume Fraction and Shape of Sulfide Inclusions on Through Thickness Ductility and Impact Energy of High Strength 4340 Plate Steel", Metallurgical Transactions A, Volume 13A, Dec 82, pp 2239-2258.
2. Aerospace Structural Metals Handbook, 1985, Metals and Ceramics Information Center, Battelle's Columbus Laboratories.
3. Honeycombe, R. W. K., and Bhadeshia, H. K. D. H., "Steels, Microstructure and Properties". 1996, Halsted Press.
4. "Strength of Materials, Effect of Different Factors on Structural Strength", Vol: 13, No: 11, Date: Nov 1981, pp 1439-1443, OCLC ISSN: 0039-2316.
5. "Strength of Materials, Effect of Rapid Heating on the Nature of Short-Term Rupture Strength", Vol: 14, No: 12, Date: Dec 1982, pp 1648-1653, OCLC ISSN: 0039-2316.

KEYWORDS: HLSA, steel, cobalt, hardening, low sulfur, Inclusions, yield strength, tensile strength, fracture toughness

AF99-196 TITLE: Innovative Techniques for Laser Radar

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop new techniques and components for imaging laser radars

DESCRIPTION: Develop laser radars or laser radar components based on techniques which promise a substantial performance improvement and/or cost reduction over current laser radar (LADAR) systems. Laser radars are useful tools for a variety of commercial and military applications. Current long-range LADAR systems rely on one of two basic schemes for finding the distance to an object: a pulsed direct detection scheme which measures the photon time-of-flight, or a scheme which measures distance based on coherent mixing of an intensity modulated output and/or return. Each of these schemes has drawbacks and limitations. For example, direct detection devices typically use single element detectors (especially at wavelengths greater than one micron) that must be scanned in order to produce 3D imagery. Slow scanning results in low imagery frame rates. Improving LADAR performance over the state-of-the-art can be accomplished either by improving the components that make up a current LADAR system, or basing a system on a new technique for range measurement. Likewise, reducing the cost of LADAR systems may be achieved through component cost reduction, or designing new systems that are inherently cheaper than existing ones. This topic invites proposals that pursue any of these paths. Proposals should address research into a new or lower-cost component for use in an existing LADAR scheme, or research into a new technique expected to result in improved performance or reduced system cost. Current LADAR components include lasers, optical detectors, optical scanners, transmit and receive optics, and ranging electronics. Techniques which lend themselves to implementation in compact packages are of great interest. Furthermore, techniques and components that can be used at near-IR to mid-IR wavelengths may allow more eyesafe operation of LADAR systems. Exploration of multi-spectral LADAR components and systems is encouraged. Proposals need not cover every aspect of a LADAR system design, but should contain enough information to make clear how the proposed component or technique fits in to a LADAR scheme that is appropriate for imaging targets at distances on the order of 1 km (or greater). Proposed schemes should be appropriate for implementation in at least a laboratory breadboard setup.

PHASE I: Investigate the performance of the proposed component or technique through modeling, construction, and experimentation with critical elements of the proposed design. The investigation results will be incorporated into a detailed prototype component or LADAR system design to be reported at the end of Phase I.

PHASE II:Phase II of this project would involve the construction and delivery of a prototype component or LADAR system based upon the design developed in Phase I.

PHASE III DUAL USE APPLICATIONS: Advances in LADAR systems and components can result in new system capabilities appropriate for a variety of uses in the military and commercial sectors. Potential commercial uses of LADAR systems include remote sensing applications for environmental monitoring, security systems, and vehicle proximity warning sensors. Potential military uses include munition seekers, airborne reconnaissance and surveillance, and targeting systems. Advances in individual LADAR components may result in a wide variety of commercial and military applications, depending upon the particular component and the nature of the advance. Lasers, optical detectors, and optical scanners have many uses in a wide range of commercial and military systems.

REFERENCES:

1. A. Jelalian, "Laser Radar Systems," Artech House, Boston, 1992.
2. Electro-Optics Handbook, RCA Solid State Division, Lancaster PA, 1974.
3. Fox, Clifton S. (ed.), "The Infrared & Electro-Optical Systems Handbook", Volume 6: "Active Electro-Optical Systems," SPIE Optical Engineering Press, Bellingham WA, 1993.
4. W.L. Wolfe and G.J. Zissis, "The Infrared Handbook," Environmental Research Institute of Michigan, Ann Arbor, 1989.

KEYWORDS: LADAR, laser radar, laser ranging, direct detection, optical scanners, optical detectors, laser applications, coherent laser radar

AF99-197 TITLE: Electron Bombardment Charge Coupled Devices (EBCCD) Development for LADAR Applications

TECHNOLOGY AREA: Sensors

OBJECTIVE: Investigate new EBCCD materials and architectures for use in imaging LADAR receivers

DESCRIPTION: The Air Force Research Laboratory Munitions Directorate has been involved in the research and development of LADAR seeker technologies suitable for air-to-air and air-to-surface munitions. Recently, increased emphasis has been placed on using high-speed, two-dimensional detector arrays to gather range and intensity images. The use of a detector array enables high (e.g. video) frame rates and reduces or eliminates mechanical scanning requirements for certain short range applications. Our LADAR receiver architectures require two essential operating characteristics of a candidate receiver array: frame rates (i.e. array read out rates) greater than 30 Hz, and gain modulation at MHz rates. We currently have LADAR systems which use an image intensifier tube that illuminates a commercially available silicon CCD array to achieve these two characteristics. The image intensifier gain can be modulated at MHz rates, while the CCD can be read out at video rates. However, for munition seeker applications, it is desirable to eliminate the image intensifier tube to save on space, cost, and improve seeker durability. Furthermore, current image intensifier/CCD architectures are limited to operation in the visible spectrum, resulting in LADAR systems that are not eyesafe. Recent advances in Electron Bombarded CCD (EBCCD) technology have made it an attractive candidate for use in LADAR receivers. Since the photocathode material is an intrinsic part of the device, it would eliminate the need for an image intensifier tube in a LADAR receiver architecture. In EBCCD devices, gain modulation can be achieved by modulating the photocathode voltage. The underlying silicon CCD array should allow for video read out rates. This topic seeks proposals that would conduct research and development into EBCCD technologies, ultimately leading to the fabrication and delivery of an EBCCD device for use in a LADAR receiver. Such a device should have an array of at least 256x256 pixels, a frame rate of 30 Hz or better, and the ability to modulate the gain at a 10 MHz rate. Proposals are encouraged that would investigate novel photocathode materials for EBCCD operation at near-IR wavelengths between 1.0 and 2.5 microns.

PHASE I: Investigate the performance of the proposed EBCCD through modeling, construction, and experimentation with critical elements of the proposed design. The investigation results would be incorporated into a detailed prototype EBCCD design to be reported at the end of Phase I.

PHASE II: Phase II of this project would involve the construction and delivery of an EBCCD prototype based upon the design investigated in Phase I.

PHASE III DUAL USE APPLICATIONS: Advances in EBCCD technologies can lead to a variety of military and commercial imaging applications. Passive imaging applications include night vision and low-light level video monitoring. Commercial active (i.e. LADAR) imaging applications include remote sensing for environmental monitoring, security systems, and vehicle proximity warning sensors. Potential military LADAR applications include munition seekers, airborne reconnaissance and surveillance sensors, and targeting systems.

REFERENCES:
1. Fox, Clifton S. (ed.), "The Infrared & Electro-Optical Systems Handbook", Volume 6: "Active Electro-Optical Systems", SPIE Optical Engineering Press, Bellingham WA, 1993.
2. Jelalian, A., "Laser Radar Systems," Artech House, Boston, 1992.
3. "Electro-Optics Handbook," RCA Solid State Division, Lancaster PA, 1974.
4. Wolfe, W.L., Zissis, G.J., "The Infrared Handbook," Environmental Research Institute of Michigan, Ann Arbor, 1989.

KEYWORDS: LADAR, EBCCD, laser radar, laser ranging, detector arrays, optical detectors, Electron Bombarded CCD

AF99-204 TITLE: Advanced Rocket Propulsion Technologies

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop innovative components, manufacturing/processing techniques, and integration technologies aimed at doubling existing rocket propulsion capabilities by the year 2010.

DESCRIPTION: There is a critical need for novel, innovative approaches to develop technologies which can double existing rocket propulsion capabilities by the year 2010, and for bold, new, nonconventional aerospace propulsion-related technologies which will revolutionize aerospace propulsion in the next century. These revolutionary concepts, based on sound scientific and engineering principles, are essential in order to increase performance and mission capability while either maintaining existing or decreasing life-cycle costs. The proposed solutions shall emphasize "dual use technologies" that clearly offer civilian/commercial as well as military applications. Proposals emphasizing "spin-on technology transfer" from the civilian/commercial sector to military applications will receive additional consideration.

Our technological goals include: 1) Improve specific impulse and mass fraction for boost and orbit transfer, spacecraft, and tactical missile propulsion. 2) Reduce the stage failure rate and hardware and support costs for boost and orbit transfer propulsion. 3) Improve the thrust-to-weight ratio for liquid rocket engines. 4) Improve the total impulse to wet mass ratio for electrostatic and electromagnetic satellite propulsion systems. 5) Improve density impulse of monopropellants for satellite propulsion systems. 6) Improve the delivered energy of tactical missile propulsion systems. In the conduct of rocket propulsion research we strive to reduce environmental hazards from propellant ingredients and processing, propulsion exhaust, and rocket motors while either maintaining or surpassing current propulsion efficiency.

Improvements in the operability, reliability, maintainability, and affordability of space launch applications, might include development of novel systems which can be launched with short lead times for a relatively low life cycle costs. Such a concept may include the design and development of a rocket-based combined cycle (RBCC) engine. Such systems would need to demonstrate high reliability and maintainability levels.

Subsets of advanced rocket technologies would have lengthy shredouts of potential research subjects but are not stated here in detail. These technologies might include the need for innovative combustion and plume diagnostics (i.e., application of electro-optical devices and sensors), performance predictions, modeling of exhaust plume radiation and combustion characterization, propellant and component service life prediction technologies, and environmental contamination.

Additionally, bold, new advanced propulsion and related technological concepts and products for space activities are solicited for development. These topics include revolutionary concepts in advanced fuels and oxidizers, metastable high energy nuclear states, storage of antimatter in chemical matrices, nanotechnology products and techniques applied to rocket propulsion, enigmatic energy devices, and field propulsion thrusters. Research in these advanced rocket propulsion topics are included and structured to provide a maximum of innovative flexibility while yielding promising commercial applications/dual-use technology applications to prospective investigators.

PHASE I: Further develop the concept and perform analyses required to establish the feasibility of the proposed approach.

PHASE II:Complete the Phase I design and develop a demonstrator or prototype. Document the R&D and develop a technology transition and/or insertion plan for future systems and commercial ventures.

PHASE III DUAL USE APPLICATIONS: Advanced rocket propulsion technologies will transition to new, higher performing and/or lower cost U.S. military and commercial rocket engines and motors or advanced propulsion systems. This will enable the U.S. aerospace industry to increase global market share for space launch opportunities by reducing the life-cycle cost and increasing the efficiency of inserting payloads in orbit. Advanced rocket propulsion technologies also serve the commercial sector by enhancing our ability to remanufacture components to maintain and monitor the health of the U.S. ballistic missile fleet.

REFERENCES: "Selected Bibliographies, Handbooks, Manuals, and Reviews," CPIA SB-94, Nov 1994 (CPIA, 10630 Little Patuxent Parkway, Suite 202, Columbia, M.D. 21044-3204)

KEYWORDS: Rocket Plume, Rocket Engine, Rocket Propellants, Advanced Propulsion, Satellite Propulsion, Boost and Orbit Transfer

AF99-205 TITLE: Aero Propulsion & Power Technology

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Explore innovative approaches for turbine and advanced propulsion systems and electrical power concepts for manned and unmanned applications.

DESCRIPTION: The Aero Propulsion & Power Directorate aggressively pursues major performance advances in all components of gas turbine engines under the Integrated High Performance Turbine Engine Technology (IHPTET) initiative. Technologies derived under this initiative have resulted in higher thrust to weight ratios and improved efficiencies. The focus of this topic is to consider those aspects in the design of gas turbine engines and other prime propulsion concepts, electrical power systems and energy storage devices that could support manned and unmanned mission requirements. The innovative approaches may include, but are not limited to, the use of microelectromechanical (MEMS) and mesoscopic machine technology. Emphasis would be on affordability, reliability, and lightweight designs without compromising range and payload. New analysis techniques, innovative designs, hybrid propulsion systems and electrical power concepts to support manned and unmanned air vehicle (UAV) applications are solicited.

PHASE I:Define the proposed concept and predict the performance of the proposed design. Explore the feasibility of a new concept or concepts, through analysis and/or small scale testing to demonstrate the merits of a flexible modular design that can meet various mission applications.

PHASE II:Provide detailed analytical derivations and prototypical device or hardware demonstrations.

PHASE III DUAL USE APPLICATIONS: UAVs can present an effective alternative for some civil sector missions, for example meteorological data gathering, atmospheric sampling and surveillance. Forest Service mapping and fire spotting, agriculture and ranching support, coastal and border patrol and surveillance, and storm tracking and disaster assessment are some specific areas that may be exploited with UAV

REFERENCES:
1. "Unmanned Vehicle Systems: Military and Civil Robots for the 21st Century & Beyond", Dr. Robert Finkelstein & Steven Shaker, Pasha Publications, 1616 North Fort Meyer Dr., Suite I 000, Arlington, VA 22209, 1994.
2. "Introduction to UAV Systems", Paul Fahlstrom and Thomas Gleason, UAV Systems Inc., 5537 Twin Knolls Rd., Suite 439, Columbia, MD 21045, 1995.
3. "FY97 Aero Propulsion & Power Technology Area", Headquarters Air Force Material Connnand, Directorate of Science & Technology, Wright-Patterson AFB OH
World Wide Web address: http://stbbs.wpafb.afmil/STBBS/info/taps/fy97/propulsn/final.doc, WL-TR-97-2000, ADA 318710.

KEYWORDS: MEMS, fuels, scramjets, lubrication, power systems, turbine engines, mesoscopic machines, High speed propulsion

AF99-206 TITLE: Directed Energy Weapon Power Technology

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop electrical power system concepts and relevant technology such as electrical power generation, power electronic conversion, energy storage (including batteries, capacitors and flywheels) and pulsed power for potential directed energy weapon systems concepts. Perform related computer analysis and simulation to understand overall component and system performance.

DESCRIPTION: The Air Force seeks innovative concepts for electrical systems, electrical power generation, power electronic conversion, and pulsed power conditioning for electrically powered directed energy weapon (DEW) concepts for potential tactical, theater, and national missile defense systems. The types of DEW systems considered in this program include high power microwaves devices, solid-state diode laser, gas lasers, radio-frequency based free electron lasers, and radio-frequency based particle beams. The power levels of these potential vehicle systems range from 100's kW up to 100's MW average power. The voltages in these systems range from 100's V for solid state based systems up to 100's kV for microwave and radio frequency based systems. The turbine generator technologies of interest in this program range from permanent magnet and switch reluctance generators at the low power range to superconducting magnet generators at the higher power levels. Direct energy conversion technologies such as magnetohydrodynamic (MHD) and electrohydrodynamic (EHD) generators will be evaluated for these platforms. The magnetic technologies of interest include light weight permanent magnets, switch reluctance electromagnets, and lighter weight superconducting magnets. The power electronic technologies of interest in this effort include cryogenically cooled components, high voltage semiconductors switches and diodes (1000's V), high voltage pulsed power switches (100's kV), high energy inductors, high voltage insulators (100's kV), and high energy capacitors (10's kJ). Computer analysis and simulation software development that combines computational fluid dynamics, thermodynamics, with magnetohydrodynamics and electrohydrodynamics equations will be important in this effort. Reduced ordered system computer models of the different generators, power converters, and pulse forming devices will be developed as part of this effort. Thermal management technologies for the systems and battery technologies will be evaluated as part of this effort.

PHASE I: Define the technical problem, identify a proposed solution, demonstrate component hardware technologies, or develop conceptual designs of components and systems.

PHASE II: Develop prototype component hardware or the detailed designs of components and systems with computer simulation software that demonstrate the performance of the system.

DUAL USE APPLICATIONS: Software and component technologies will have potential commercial applications for high power and high voltage generators and power electronics used in utility power systems, and civilian space missions.

REFERENCES:
1. G. Kozlowski, C. E. Oberly and I. Maartense, Effect of YBaCuO substrate on electromagnetic properties of Melt Processed Y Ba2Cu3 Ox Superconductor, Adv. in Cryo. Eng. (Materials) Vol 41.
2. O. Mueller, K. G. Herd, Ultra-High Efficiency Power Conversion Using Cryogenic MOSFETs and PESC 1993 Conference Proceedings, pp 772-778.
3. Berry, G. Users Manual for MGMHD: A Multi-Grid 3D Code for Analysis of MHD Generators and Diffusers, Argonne National Laboratory Report MHD/89/1, IEEE 24th Annual Power Conference, IEEE Sctvice Center, Piscatawy NJ. NASA Technical Report 90N16526, NTIS-DE 90004453.

KEYWORDS: capacitors, electric power, Power generation, thermal management, electrohydrodynamics, magnetohydrodynamics, superconducting generators

AF99-207 TITLE: Micro-System Technologies for Advanced Aerospace Vehicle Power Systems

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Demonstrate the pervasive use of Microelectromechanical Systems (MEMS) technologies in aerospace power systems.

DESCRIPTION: There are many challenges in transitioning Microelectromechanical Systems (MEMS) technologies to specific applications that will benefit in cost, weight, manufacturing, reliability, etc. MEMS devices to date have had limited evolution from novel micro-devices to specific applications such as micro-sensors. For the most part, the development of micro-sensors such as accelerometers, pressure sensors, and the like have been the primary focus for transitioning this micro-technology to real world applications. Barriers to applying MEMS technologies in specific applications other than micro-sensors have been; (a) gaining access to fabrication facilities and (b) combining the diverse technical expertise required to leverage MEMS technologies to a variety of applications. The use of innovative micro-systems integral to aerospace vehicle prime power and secondary power systems must be widened, which will result in system level benefits. These innovative micro-systems may incorporate, but not be limited to, such approaches as micro sensing for diagnostic surveillance, micro-fluidics for thermal control, or microscale control of macroscale processes. These systems for current and future aerospace vehicles.

Proof of concept for microscopic batteries to provide power for MEMS applications has been shown by previous work. One of the focuses of this topic is to consider the integration of microscopic power sources, such as batteries, fuel cells, solar cells, etc., directly into actual MEMS devices. Innovative devices may include existing battery technology or include new couples or batteries specifically designed for microscopic or MEMS applications. Such devices may include, but not be limited to, any couple, any physical state (solid, liquid or gas), or any electrolyte. Emphasis would be on affordability, reliability, and operation over a wide range of temperature, pressure, and vibrational conditions, as well as manufacturability and integration potential with MEMS devices.

PHASE I: Include a feasibility demonstration, either analytical or experimental, of the proposed micro-system concept, address integration issues, and provide sufficient analysis to demonstrate prime power system or secondary power system level payoffs.

PHASE II: Include sufficient demonstration of the proposed micro-system concept to show integration viability into an aerospace vehicle prime power system or secondary power system.

PHASE III DUAL USE APPLICATIONS: The development, demonstration , and integration of robust micro-systems into aerospace vehicles represents numerous technical challenges requiring innovative solutions which in turn can be directly applied in the military and private sectors.

REFERENCE:

1. Ameel, T.A., Warrington, R.O., Wegeng, R.S., and Drost, M.K., 1997, "Miniaturization Technologies Applied to Energy Systems," Energy Convers. Mgmt., Vol. 38, No. 10-13, pp. 969-982.
2. Feasibility of Micro Power Supplies for MEMS, P.B. Koeneman, I Busch-Visniac, and K. Wood, Journal of Microelectromechanical Systems, Vol 6, No 4, (1997), 355-362.

KEYWORDS: MEMS, sensors, batteries, actuation, fuel cells, motor control, flight control, micro-fluidics, electric motors, power generation, power electronics, thermal management

AF99-208 TITLE: UAV Electrochemical Propulsion Power and Energy Storage

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop lightweight, long duration electrochemical propulsive power and energy storage systems for UAV flight platforms.

DESCRIPTION: This topic seeks proposals with innovative concepts related to electrochemically powered (batteries and/or fuel cells) unmanned aerial vehicles (UAVs). Electrochemical propulsive power and energy storage systems are sought since they can provide lightweight, cost-effective, low-observable solutions to the power/energy storage needs for UAV platforms. The power requirements can range from several watts for microelectromechanical systems (MEMS) to tens/hundreds of kilowatts for large high- altitude long-endurance (HALE) reconnaissance/directed energy weapons platforms. The mission times range from several hours/days for primary power applications to months/years for solar regenerative applications. Rechargeable energy storage capacities greater than 250 watt-hours/kilogram are desired. Electrochemical propulsive power weight goals are mission dependent, however, doubling the energy density compared to existing propulsion systems is the desired goal.

PHASE I: Define the proposed concept, predict the performance of the proposed design, and through analysis and sub-scale testing, demonstrate that the proposed design can meet the desired weight goal for the UAV mission application.

PHASE II:Provide an operable prototype component or system that is completely suitable for the intended application. The prime consideration must be deliverable hardware and a clear demonstration of a manufacturable device, component or system that improves the existing technology either through exceptionally high performance, significantly reduced cost, or improved robustness.

PHASE III DUAL USE APPLICATIONS: Electrochemical batteries and fuel cells for UAV's would be utilized in civilian UAV's, electric vehicles, and various other portable power applications.

REFERENCES:

1. P.B. Koenenman, I.J. Busch-Vishniac, and K.L. Wood, Feasibility of Micro Power supplies for MEMS, Journal of Microelectromechanical Systems, Vol. 6, No. 4, Dec 97, pp355-362.
2. K.C. Reinhardt, T.R. Lamp, and A.J. Colozza, Solar-Powered Unmanned Aerial Vehicles, 31st International Energy Conversion Engineering Conference, Washington DC, Aug 11-16, 96.
3. S.F. Brown, The Eternal Airplane, Popular Science Magazine, V. 244, 4 Apr 94, p.70.
4. S.F. Brown, The Eternal Airplane, AIAA Student Journal Spring 1996 v.34 n.l. p.2.

KEYWORDS: UAV, fuel, cell, power, battery, energy storage, electrochemical

AF99-209 TITLE: Power Generation and Thermal Management

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop techniques, devices and components for aerospace power generation and thermal management/control.

DESCRIPTION: Electrical machines are needed that operate at high speeds (30-70 krpm) while generating power up to 300 kW for Auxiliary Power Unit (APU) and main engine applications. A machine running at higher speed can usually attain a higher power density and lower weight. However, a high power density motor or generator poses difficult technical challenges generally associated with the generation of high heat loads from magnetic and electrical losses and windage. Proposals are solicited which offer ways to either reduce these heat loads, or to ameliorate their effects. Examples of areas of interest include, but are not limited to, high temperature windings and potting materials (>400 degrees C, 600 degrees C goal) for switched reluctance machines (SRMs), fault tolerant winding configurations for permanent magnet (PM) generators, non-lubricated active or passive rotor suspension systems (including hybrids) for APUs, and on-line diagnostic approaches for monitoring/controlling APU rotor/bearing system stability.

Innovative thermal management concepts are sought in the areas of high power electronics and rotating machine cooling. More Electric Aircraft (MEA) power system components possess unique environments which preclude conventional cooling approaches. Concepts that integrate the cooling and electronics package are desired for their effective and compact nature. In general, passive concepts are desired over active concepts. Passive thermal management concepts for high performance aircraft have the potential of being reliable and simplistic in design, and are therefore preferred. However, such concepts must manage the inherent coupling of transient heat generation and transient acceleration-induced forces, and their effects on the cooling performance of the device. When active cooling is proposed, air is the most desirable coolant while existing aircraft fluids such as JP-8 fuel, polyalphaolefin, or MIL-standard lubricants will suffice if the cooling system is conceived as a line replaceable unit (LRU) or is modular. Reduction of Life Cycle Costs (LCC) should be a key objective for all efforts. For air cooling, low pressure drop approaches that are integral with the electronics package are desirable. The effects of altitude or the impact of the use of compressor bleed air must be addressed when air cooling is proposed. Areas of interest include but are not limited to, two-phase cooling, immersion cooling, heat pipes, heat exchangers with enhanced heat transfer surfaces, and the use of micro electro-mechanical systems (MEMS) to control and enhance interfacial heat transfer.

Other concepts are sought for selecting and demonstrating materials which offer the potential of both ac and dc superconducting operating capability at liquid nitrogen temperature, in magnetic fields greater than three tesla, and at current densities greater than 100,000 amps per square centimeter. Cryogenic power converters are needed which are compatible with aircraft voltage of 270 Vdc, operate at temperatures of 77-150K, demonstrate efficiencies of 99% or better, and demonstrate power densities greater than 1,600 watts per cubic inch at power levels above 300 kW. High voltage aircraft technologies include innovative approaches for system insulation, high electric field dielectrics and insulation aging characterization. Concepts are also sought involving electromagnetic effects, including the assessment of the survivability/vulnerability of More Electric Aircraft (MEA) circuits to both manmade and natural electromagnetic threats.

PHASE I: Develop a detailed technical definition of the problem, identify a proposed solution, and demonstrate the key technologies enabling the use of that solution.

PHASE II: Concentrate on development of prototype components, subsystem demonstrations, and hardware development.

PHASE III DUAL USE APPLICATIONS: These technologies have application for all high speed motors, generators, actuators, and power electronics which may be used in future high power density electric/hybrid transportation vehicles (commercial air, high speed rail, and electric car), power generation, and manufacturing facilities.

REFERENCES:
1. "Prediction of Windage Power Loss in Alternators," NASA TN D 4849, James E. Vrancik, NASA Lewis Research Center, Oct., 1998, N68-37162, NTIS, 5285 Port Royal Road, Springfield, VA.
2. "High Temperature Generator Development," AFAPL TR 74 69, Robert Fear, et al., Westinghouse Electric Corporation, AD-786 046; NTIS, 5285 Port Royal Rd., Springfield, VA.
3. "Cooling Down Hot New Electronics," Leland, J.E., Price, D.C., Hill, B.P. and Collicott, H.E., Aerospace America, Vol.33, No.6, pp. 40 44, 1995.

KEYWORDS: Power generation, actuator cooling, thermal management, electronics cooling, fault tolerant PM machines, switched reluctance machines

AF99-210 TITLE: Advanced Dielectrics and Capacitor Devices

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop innovative dielectric materials and/or capacitor devices with superior electrical and thermal properties over the current state of the art in one or more of three distinct and different thermal operating environments:
(1) -55 degrees C to > 300 degrees C
(2) 20K to 240K
(3) -55 degrees C to 125 degrees C

DESCRIPTION:

High temperature power electronics systems will be a pervasive technology in the next generation of weapon systems. Typical power systems include motor drives, inverters and converters for switched reluctance starter/generator systems, dc to ac inverters, dc to dc converters, and pulse forming networks. Common to all of these systems are capacitors, which are numerous, and are critical to the operation of the system. Today's capacitors are the weakest link in power electronic system reliability and are currently limited in temperature capability to a maximum of 125 degrees C. Current application temperatures range from -55 to 200 degrees C and some applications may require > 300 degree C operation with superior electrical performance. Attention to lowering the leakage currents, lowering the dissipation factor, increasing the voltage breakdown strength and increasing the dielectric constant over the current state of the art is desired. For integrated passives, attention to lowering the dissipation factor and leakage currents is paramount. Candidate proposals shall address novel and innovative high temperature dielectrics and/or high density packaging and/or manufacturing technologies to reduce cost. A large range of specific uses include dc and ac power filtering, energy storage, high repetition rate (pulse power) devices, high energy back-up or hold-up power devices, and small signal (SMT, MCM, etc.) capacitor applications for controls.

Cryogenic capacitor devices operating in the More Electric Aircraft (MEA), specifically in the temperature range of 20K to 240K, are of interest. These cryogenic systems include capacitor devices in motors, generators, power conditioning and distribution circuits and energy storage networks (PFN), etc. The same superior electrical properties are desired for the cryogenic area as listed for the high temperature environment.

For electrochemical capacitor device development, the proposal can focus either on energy density or power density, or both objectives can be addressed. Energy density should exceed 250 J/cm3 while the peak power density should exceed 30 W/cm3. An equivalent series resistance below 10 m should be an objective, as should improved cycle life (>1 million cycles). An optional objective could also be the increase in maximum cell voltage (above 2.5 V). Power electronics development proposals will also be entertained which deal with chargers/converters designed to meet the unique characteristics of electrochemical capacitors and that pertain to any of the applications listed in this topic.

PHASE I: Demonstrate innovative capacitor approaches with substantial improvement in capacity, dielectric constant, voltage breakdown strength, dissipation factor, and temperature capabilities. Prototype laboratory capacitors should be fabricated and tested to demonstrate the feasibility of the technology.

PHASE II:Demonstrate development of prototype capacitor components using innovative dielectric material or advanced high density packaging or manufacturing technology or a combination thereof. Actual application testing should be performed and electrical, thermal and life assessments made.

PHASE III DUAL USE APPLICATIONS: Capacitors are used in nearly every commercial and military system that consumes electrical power. Potential applications include all consumer electronics, medical electronics including defibrillators, automotive electronics including electric vehicles and electric utilities. High temperature applications include aircraft engine ignition systems and electrical actuation, deep oil well instrumentation, and under the hood automotive applications.

REFERENCES:

1. Brudar, J., "Solid State Electrochemical Capacitors," Vol 3, Florida Educational Seminars, Inc., Boca FL, 1983.

2. Pratt, Eric, "Trends in Ceramic Chip Capacitors for Military Applications, Surface Mount Technology", Vol 5, No. 10, Oct 1991, pages 39-40.

3. Peters, A., "Power Capacitors - New Developments," IEEE Colloquium on Capacitors for Inductors for Power Electronics," IEEE, London UK, 1996.

4. Das-Gupta, D. R., Zhang Shuren, "Non-Polar Polymer/Ferro and Antiferroelectric Ceramic Composite Films for High Energy Storage Capacitors," 2nd European Conference on the Application of Polar Dielectrics, Journal of Ferroelectrics, Vol 134, No. 1-4, pages 71-76, 1992.

KEYWORDS: capacitors, electrodes, Dielectrics, pulse power, electrolytes

AF99-211 TITLE: Integral Superconducting Electrical Power Generator for Rocket Turbopumps

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Conduct analysis to determine viability of replacing existing pneumatic and hydraulic rocket engine control systems and/or boost pumbs with electrically powered superconducting based systems. Address issues of cost, weight, reliability, and maintainability. Demonstrate the technologies required to integrate a superconducting electrical power generator into cryogenic rocket engine turbomachinery.

DESCRIPTION: Modern aircraft gas turbine engines routinely use shaft power to generate electrical power for the host aircraft. Current rocket engines use separate auxiliary power units to provide power to hydraulic systems which actuate valves or use stored gas systems to power pneumatically actuated valves. In either case, a weight and volume penalty is incurred due to the need to provide power to control system actuators. The availability of a significant source of electrical power would allow for the use of smaller, lighter-weight electromagnetically actuated valves. Elimination of hydraulic or pneumatic systems would also eliminate control system specific leaks and simplify control system maintenance and health monitoring.

PHASE I: (a) Consult with cryogenic rocket engine manufacturers and users to identify potential rocket engine electrical power requirements based on the potential electrical power users identified above. (b) Conduct a survey of superconducting materials and generators to determine the viability of the concept of a light weight, compact, high power superconducting generator at temperatures typically found in cryogenic turbomachinery. (c) Identify requirements for an integral superconducting electrical power generator for rocket turbopumps. (d) Consult with cryogenic rocket engine manufacturers and prepare conceptual designs to fulfill the identified requirements. (e) Among competing conceptual designs, select the most promising and initiate a preliminary design. (f) Prepare a test plan to demonstrate the validity of the design in a simulated cryogenic turbopump environment.

PHASE II: (a) Finalize the design selected in Phase I. (b) Manufacture prototype test hardware. (c) Conduct testing in a simulate or actual cryogenic rocket propellants using test plan developed in phase I. (d) Review results of testing and consult with cryogenic rocket engine manufacturers and users. (e) Identify any prototype modifications needed to meet established requirements. (f) Conduct market analysis to determine marketability of product and identify market base/competitors. (g) Modify design as required. (h) Re-accomplish testing as required and create manufacturing plan.

PHASE III DUAL USE APPLICATIONS: Any technology developed for military spacecraft can also be used in commercial spacecraft. These technologies also have wide application in terrestrial systems, such as hybrid or all electric vehicles, remote site power, building/home secondary power supplies, and power plants. The primary military application is to reduce satellite power system mass, volume, and cost to increase payload mass and power budgets and reduce satellite and launch vehicle costs.

REFERENCES:

1. Superconducting Technology Program, Sandia 1993 Annual Report, SAND94-1279

2. High-Temperature Superconducting Motor using Y-Ba-Cu-O Bulk Magnets, Japan Journal of Applied Physics Vol. 34 (1995), Part 1, No. 10, pp. 5574-5578, October 1995.

3. Public information available from vendors such as Reliance Electric of Cleveland, OH on the internet at http://www.reliance.com/prodserv/motgen/b2776_1.htm

KEYWORDS: Electric APU, Cryogenic APU, Rocket Propulsion, Superconducting APU, Cryogenic Generator, Electrical Generator, Auxiliaray Power Unit, Superconducting Generator, Superconducting Electric Generator

AF99-212 TITLE: High Performance Oxidizer System for Hybrid Missiles

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop and demonstrate an environmentally clean, non-toxic, high performance oxidizer system for use in hybrid tactical missiles. The tactical thermal environment is -65oF to +165oF

DESCRIPTION: A recent Air Force Research Laboratory study demonstrated that missiles using hybrid propulsion have the potential to make significant gains in performance over more conventional approaches. In hybrid propulsion, unlike a solid rocket motor, fuel and oxidizer are separated until mixed in a combustion chamber. Innovative approaches are needed to create oxidizers and expulsion systems that meet requirements for future missiles systems. These requirements demand systems which are able to perform in extremes of temperature, are non-toxic and safe, behave as insensitive munitions, and are capable of high performance. In tactical missiles, high performance entails both high density and high oxidizing capability. Oxidizer systems that can meet these standards, whether they are gelled liquids, slurries of liquids and solids, or some other innovative combination, are vital to improved performance in future missiles.

PHASE I: Develop and characterize the oxidizing chemical to be used in the hybrid missile. The candidate oxidizer would first be screened theoretically to verify that it has the potential for the high performance needed in a tactical system. It is expected that the oxygen balance, toxicity, storability, and hazards of the material would be determined through laboratory analytical techniques. The suitability of this chemical relative to tactical requirements would then be determined. Once the basic nature of the oxidizer is determined, a conceptual design of the oxidizer expulsion system would be undertaken. As a result of Phase I of this effort, the awardee would have produced and demonstrated, in the laboratory, a promising oxidizer and have an initial design of an oxidizer expulsion system for hybrid tactical missiles.

PHASE II:The volume of chemical oxidizer produced would be scaled up to quantities suitable for testing in tactical motors. A low cost synthesis method would be demonstrated. The expulsion system designed in Phase I would be built and tested. The expulsion rate, pressure, spray characteristics, and efficiency would be measured. At the end of this phase, a live firing of a tactical size hybrid motor using the oxidizer system that was developed and a suitable fuel would be expected.

PHASE III DUAL USE APPLICATIONS: The results of a successful Phase II program would result in technologies that would find a wide variety of commercial uses. Car airbags and other safety devices represent a large market that needs similar ability to deploy gases quickly and efficiency. Other commercial products include various combustion devices such as torches, welders, emergency generators.

REFERENCE:

1. Lawless, E. W., et al., Inorganic High-Energy Oxidizers, Marcel Dekker, Inc., New York, 1968.
2. Sutton, G. P., Rocket Propulsion Elements, John Wiley & Sons, Inc., New York, 1992.

KEYWORDS: Rocket, Hybrid, Oxidizer, Propellants, Expulsion system

AF99-213 TITLE: Solar Thermal Rocket Propulsion

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop novel solar thermal propulsion components and technologies.

DESCRIPTION: The solar thermal rocket propulsion concept is to develop and Orbit Transfer Vehicle (OTV) to perform the mission of boosting payloads from low earth orbit to geosynchronous orbit (GEO). An OTV based on a high specific impulse solar rocket engine has the ability to deliver twice the payload to GEO as current chemical upper stages. Solar rocket engines generally consist of two paraboloid reflectors which concentrate sunlight into a small high temperature heat exchanger. Hydrogen gas is heated by flowing through the exchanger and produces thrust by accelerating out a nozzle.

To be practical for AF missions, the mass and packaging volume of the OTV must be kept to a minimum. This has led to the use of thin film inflatable concentrators and suppoprt struts that deploy and rigidize once in orbit. The concentrators consist of two films attached at the edge to form a clamshell. The first film simply holds the very low pressure gas against the second film that is the reflector. To make this type of reflector viable, it must be able to deploy and maintain a shape to a fairly tight accuracy. It must also have sufficient stiffness to be controllable and be resistant to the space environment. This includes micro-meteroids, atomic oxygen, and UV radiation. Novel ideas such as methods to rigidize the thin film are needed to provide 30-day life requirement. Other areas of interest are ways to keep the films from tearing, ways to self seal punctures, ideas to keep wrinkles fron forming during packaging, and ways to fine tune the support struts once in orbit. There is also a need for a method of measuring or sensing the shape and accuracy of the concentrator once deployed. This would allow a space experiment to deploy an inflatable reflector and determine the shape and optical path qualities including reflectivity, vibrations, wrinkling, shape error, pointing errors, and support effects.

Another major component ripe for innovative solutions is the high temperature heat exchanger. Operational systems need to run between 2000K and 3500K. This presents the challenge of designing and manufacturing a device which can operate at the temperature, be compatible with hydrogen, and provide hundreds of cycles and hundreds of hours of operation over a 30-day mission. Furthermore, the design must get as much of the energy to the propellant as possible. This requires very good high temperature insulation, a very small entrance aperature to the exchanger, a high ratio of absortivity to emissivity, or a design that can perform efficiently without one of those. Generally, a secondary optic is placed at the entrance aperature to further concentrate the incoming sunlight. Although its smaller size makes weight less of a concern, the reflectivity is very important and it must operate at moderately high temperatures or be designed to operate cool in close proximity to the high temperature exchanger. Due to the multi-impulse burn profile of the solar OTC concept, a heat storage device can have attractive benefits. Hence, novel ideas concerning high temperature heat storage such as phase change materials are also of interest. There are issues needing attention which concern the ground testing of these engines. A method is needed to remotely monitor the surface temperature of the high temperature heat exchanger. This includes both the chamber and nozzle temperatures as viewed from down stream, and the absorbing surface of the exchanger which is flooded by intense sunlight. Furthermore, a characterization of the velocity profile of the exhaust plume is needed since the very small nozzle throat has significant influence on the flow.

PHASE I: Analyze the design or idea and perform tradeoffs. Factors to be considered should include ease of use and ability to manufacture, effectiveness of solving targeted problem, cost, reliability, efficiency, and overall benefit to the Air Force goal of developing a high ISP, light weight solar rocket. The most promising designs and methods should be validated by laboratory demonstrations or by detailing how state of the art technology is sufficient for the application.

PHASE II:Further develop, design, fabricate, and demonstrate the chosen Phase I design/concept/method. The advantage and performance of the manufactured components should be evident or be designed to be easily tested and proven by the contractor or government. The contractor shall deliver any hardware/software developed, document the work performed and develop a plan for technology transition and insertion into future systems and other commercial ventures.

PHASE III DUAL USE APPLICATIONS: The high temperature materials, thin film materials, and their manufacturing processes developed under this program will be useful for many civilian products developed by diverse industries at significant cost savings. For example, automotive, power plant, and refining industries need high temperature materials to prolong the life and reduce the cost of many products. The thin film precision materials and processes have many space applications where weight and volume are significant concerns.

REFERENCES:
1. G. Mark Skibinski, "The Effects of Space Debris on Solar Propulsion," 1991 ASME Conference, Solar Engineering Proceedings, Reno NV, February 1991.
2. R. Bradford, "Research on Large, Highly Accurate, Inflatable Reflectors," Technical Report No. AFRPL-TR-84-040, Spectra Research, Huntsville, AL, July 1984 (AD: A145 080).
3. J. M. Shoji, "Solar Rocket Component Study," Technical Report No. AFRPL-TR-84-057, Rocketdyne Division Canoga Park, CA, February 1985 (AD: A154 186).
4. Anne K. St. Clair, Tery L. St. Clair, Wayne S. Slemp, Kezian S. Ezzell, "Optically Transparent/Colorless Polyimides," NASA Technical MEMO 87650, NASA-Langley Research Center, December 1985.

KEYWORDS: Concentrators, Black Body Cavities, Direct Gain Absorbers, Solar Thermal Propulsion, Cryogenic Propellant Tanks, Geosynchronous Orbit (GEO), Orbit Transfer Vehicle (OTV)

AF99-214 TITLE: Electric propulsion thruster for low power small satellites

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop and validate innovative design concepts for low power electric propulsion thrusters applicable to small satellites.

DESCRIPTION: Small satellites are extremely mass and power limited. In addition, propulsion system requirements for this class of satellite will be high due to: larger maneuvering requirements, higher precision attitude control, increased stationkeeping life, and higher drag make-up for low orbit satellites. Substantial improvements in both thruster performance and specific power are needed to provide this increased propulsion system capability while constrained by large mass and power limitations. The objective of this effort is to radically push the technological envelope in the field of electric propulsion. Proposed concepts must show promise of more efficiently utilizing the on-board electrical energy while maintaining high specific impulse operation. Projects proposing enhancements to existing systems will also be considered. The propulsion system should be sized for satellite masses from 500 lbm down to 10 lbm with satellite specific powers from 1 to 4 W/kg.

A strong emphasis should be placed on the validation of the design that is expected to provide the stated performance enhancements; experimental and theoretical methods can be considered. Government and commercial test and evaluation facilities may be utilized; documentation of efforts to secure these facilities should be provided. Based on the results of these tests, thruster performance should be estimated and improvements quantified.

PHASE I: Develop innovative electric propulsion thruster concepts and validate critical design features for small satellite (500 lbm to 10 lbm) applications: primary interests are performance, thrust-to-weight ratio, minimal impact on spacecraft operations and systems, minimal spacecraft contamination, environmental compatibility, and lifetime. The focus of the effort should be on stationkeeping and orbit maneuvering applications.

PHASE II:Apply the results of Phase I to the design, fabrication, experimental validation, and optimization of EP thruster performance capabilities. The design process is expected to be iterative with the thruster with the best overall performance being reproduced and be deliverable at the end of the Phase II period.

PHASE III DUAL USE APPLICATIONS: Dual use commercialization would occur through the development of flight quality electric propulsion systems for small satellite and space experiment applications. The development of small satellites, and their propulsion systems, is one avenue for reducing satellite launch costs. The higher performance thrusters will result in greater mission capability including both satellite life and maneuverability, which are areas of interest to government and commercial customers. Both mission capability and profitability will increase through the introduction of these thrusters into the marketplace. The outlook for commercialization therefore appears very strong.

REFERENCES:
1. Stephenson, R.R., "Electric Propulsion Development and Application in the United States," IEPC Paper 95-1, Sept. 1995.
2. Antropov, N.N. et al., "Preliminary Results on Service Life Development of PPT Scale Model," IEPC Paper 95-114, Sept. 1995.
3. McLean, C.H. el al., "Life Demonstration of a 600-Second Mission Average Arcjet," AIAA Paper 94-2866, June 1994.
4. Garner, C.E. et al., "Cyclic Endurance Test of a SPT-100 Stationary Plasma Thruster," AIAA Paper 94-2856, June 1994.
5. Sankovic, J.M. et al., "Operating Characteristics of the Russian D-55 Thruster with Anode Layer," AIAA Paper 94-3011, June 1994.

KEYWORDS: Ion Engines, Service Life, Stationkeeping, ARC Jet Engines, Specific Impulse, Performance Tests, Electric Propulsion, Electrothermal Engines, Electromagnetic Propulsion

AF99-215 TITLE: Cryogenic Boost Pump with Integral Superconducting Electric Motor

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop novel superconducting boostpump components and technologies for cryogenically fueled aerospace vehicles.

DESCRIPTION: Boost pumps are required to avoid cavitation in high-speed turbopumps fed from low pressure, lightweight vehicle tanks. Typical rocket engine boost pumps require high pressure propellant lines to supply the turbine drive fluid which adds weight and complexity to the engine system. This could be avoided through the use of a tank-mounted electrically driven boost pump. The source of power for such a boost pump might be a generator mounted on the main turbopump which could use a superconducting current path running along the cryogenic propellant lines to feed the boost pump motor. Use of an electrically driven superconducting boost pump could reduce overall system weight, volume, and provide numerous other system benefits.

PHASE I: (a) Consult with cryogenic rocket engine manufacturers and users to identify boost pump requirements. (b) Prepare conceptual designs to fulfill the identified requirements and identify the payoffs and liabilities of each design. (c) Evaluate all conceptual designs and select the most promising for further development. (d) Prepare a test plan to demonstrate the validity of the design in a simulated cryogenic turbopump environment.

PHASE II: (a) Finalize the design selected in Phase I. (b) Manufacture prototype test hardware. (c) Conduct testing Magnetohydrodynamics in simulate or actual cryogenic rocket propellants using test plan developed in Phase I. (d) Review results of testing and consult with cryogenic rocket engine manufacturers and users. (e) Identify any prototype modifications needed to meet established requirements. (f) Conduct market analysis to determine marketability of product and identify market base/competitors. (g) Modify design as required. (h) Re-accomplish testing as required and create manufacturing plan.

PHASE III DUAL USE APPLICATIONS: Advanced boost pump technologies will transition to new, higher performing and/or lower cost U.S. Military and commercial rocket engines or advanced propulsion systems. This will enable the U.S. aerospace industry to increase global market share for space launch opportunities by reducing the life-cycle cost and increasing the efficiency of inserting payloads in orbit and moving payloads among different orbits. Advanced boost pump technologies may also serve the commercial sector by enabling the ability to remanufacture satellites already on orbit.

REFERENCES:
1. Atsumi M., Niu K., and Yokoyama M., "The Experimental Study of Electric Boost Pump for Space Transfer Vehicle," AIAA paper 93-2122, AIAA/SAE/ASME/ASEE 29th Joint Propulsion Conference and Exhibit, June 28-30 Monterey, CA
2. Superconducting Technology Program, Sandia 1993 Annual Report, SAND94-1279 (NTIS, 5285 Port Royal Road, Springfield, VA.
3. Public information available from vendors such as Reliance Electric of Cleveland, OH on the internet at http://www.reliance.com/prodserv/motgen/b2776_1.htm

KEYWORDS: Boost Pump, Cryogenic Motor, Rocket Propulsion, Electric Boost Pump, Rocket Engine Boost Pump, Superconducting Electric Motor

AF99-216 TITLE: Innovative Design of Pulse Detonation Engines

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop design methodologies for innovative pulse detonation propulsion devices.

DESCRIPTION: The Pulsed Detonation Engine (PDE) is widely recognized as a promising concept for aerospace transportation that can revolutionize propulsion in the next century. The PDE is considered advantageous for a wide range of propulsion applications ranging from boosters and upper stages through interceptor divert engines to micro-propulsion for spacecraft and Unmanned Air Vehicle (UAV's). Such devices offer a range of potential advantages compared with traditional deflagration based propulsion systems, e.g., simplicity (few moving parts), low cost (through modular design), high performance with a wide range of fuels, high thrust-to-weight (no high pressure pumps and compressors), high turn down ratio,

simple thrust vectoring, no requirement for exotic materials etc. Although a number of such devices are currently being fabricated and tested, validated design methods and scaling laws for PDE's do not exist. Nor, is there a demonstrated understanding of the parameters which control and limit achievable performance. The timely and successful development of pulse detonation propulsion devices will ultimately depend upon the resolution of these fundamental issues. This is especially true for PDE's based on liquid fuels (an attractive alternative to current gaseous-fueled systems) as the effect of fuel and injection characteristics on detonation initiation and deflagration-to-detonation transition are virtually unknown. Thus, there is a critical need for development and validation of an innovative PDE design methodology and scaling laws for multi-phase systems. In addition to combustion related issues, this methodology should also address engine/airframe integration, noise reduction, and structural loads resulting from the oscillatory nature of PDE operation. Combined with a realistic assessment of Air Force propulsion needs, a validated design methodology will enable the identification of realistic goals for new engine development, the most advantageous applications, and key technological barriers to be overcome.
The proposed research shall emphasize dual use technologies that clearly offer civilian/commercial as well as military applications. Proposals emphasizing spin-on technology transfer from the civilian/commercial sector to military applications will receive additional consideration.

PHASE I: Develop an advanced design methodology for a broad spectrum of pulse detonation applications and conduct a limited bench scale validation effort.

PHASE II: Use the Phase 1 design methodology to design an innovative, high payoff propulsion device that addresses a defined Air Force mission requirement. Fabricate a sub-scale test device that represents a convincing demonstration of the ability to design a full scale system capable of meeting Air Force Requirements.

PHASE III DUAL USE APPLICATIONS: Transition device into flight weight demonstration. Explore use of design methodology to produce innovative designs that fulfill commercial sector space propulsion requirements.

REFERENCES:
1. Eidelman S., "Pulsed Detonation Engine: A Status Review and Technology Development Road Map," AIAA 97-2740, Seattle, WA, 1997.
2. Sterling J., et al, "Numerical Investigation of Pulsed Detonation Wave Engine," AIAA 95-2479, San Diego, CA 1995.
3. Cambier J. L., et al, "Strategies for PDE Performance Optimization", AIAA 97-2643, Seattle, WA, 1997.
4. Bussing T.R.A, Bratkovich, T.E., and Hinkey, J.B., " Practical Implementation of Pulsed Detonation Engines," AIAA 97-2748, Seattle, WA, 1997.

KEYWORDS: Boosters, Liquid Fuels, Pulsed Detonation Engine, Spin-On Technology Transfer, Unmanned Air Vehicle (UAV's), Pulse Detonation Propulsion Devices

AF99-217 TITLE: Multi-Mode Propulsion Technology Development

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop and demonstrate technologies for a multi-mode rocket-airbreathing propulsion system concept.

DESCRIPTION: The Air Force is interested in the performance potential and inherent simplicity of multi-mode propulsion systems. The technology area has usually been represented by Rocket Based Combined Cycle (RBCC) engines, also known as Air Augmented Rocket engines. Pulse Detonation Propulsion (PDP) technologies also may be ideally suited for multi-mode propulsion systems. In either case, the key advantages stem from the use of a single flow path for multiple operating modes.

RBCC propulsion technologies have been demonstrated at various levels of maturity over the past few decades. Thus far, PDP technology development efforts have been conducted separately for rocket and airbreathing variants. Rocket PDP technologies are being developed for spacelift and orbital transfer applications. Airbreathing PDP technologies are being developed for very low cost propulsion systems.

A multi-mode propulsion system should combine the high thrust loading of a rocket mode with the high efficiency of an airbreathing mode. The main benefit of a multi-mode engine, as opposed to separate rocket and airbreathing engines, would be the high volumetric efficiency and low weight of a single flow path used for multiple operating modes.
Several applications appear to be suitable for multi-mode propulsion systems:

A trans-atmospheric vehicle ascending to space would launch in rocket mode, transition to airbreathing mode for atmospheric acceleration, and then revert to rocket mode for spaceflight. The airbreathing mode would also be used for atmospheric cruise after reentry from orbit.

A missile or unmanned aerial vehicle would launch and accelerate in rocket mode and then transition to airbreathing mode for atmospheric cruise. In this case, a multi-mode engine would eliminate the need for separate rocket booster and airbreathing sustainer propulsion systems.

This effort will advance the state-of-the-art of multi-mode rocket-airbreathing propulsion technologies for military applications. Successful efforts will result in the development and demonstration of technologies for the entire propulsion system, including the following key subsets:

Air induction (inlets, diffusers, compressors)
Combustion (ramburners, thrust chambers, pulse initiators, pulse detonation tubes)
Control (timing, sensors, diagnostics, operating modes)
Nozzle (manifolds, mixers, expansion surfaces or devices)
Propellant (fuels and oxidizers, preferably non-cryogenic)
Propellant system (pumps, plumbing, heat exchangers, injectors)
Structure (thermal protection, vibration control)

PHASE I: Predict the performance parameters and physical characteristics of one or more multi-mode propulsion system concepts. Evaluate these parameters against the expected values for competitive rocket and airbreathing propulsion systems. Derive technology demonstration goals for key subsets of multimode propulsion technology. Report on the feasibility of multi-mode propulsion systems.

PHASE II: A complete demonstration of the technologies for a multi-mode propulsion system will most likely require multiple SBIR efforts. Each effort should experimentally verify the Phase I performance projections for key subsets of multi-mode propulsion technology. Demonstration efforts will probably employ ground testing in direct connect and/or freejet propulsion test facilities. Subsequent efforts would include freejet test and/or flight test of an integrated multi-mode propulsion system.

PHASE III DUAL USE APPLICATIONS: If successful, multi-mode propulsion systems will be applicable to military and civil space launch systems, trans-atmospheric vehicles, and high speed transport aircraft.

REFERENCES:
1. Cambier J. L., et al, "Strategies for PDE Performance Optimization", AIAA 97-2643, Seattle WA.1997.
2. Pulse detonation engine theory and concepts, Bussing, Thomas; Pappas, George (Adroit Systems, Inc., Washington, DC), In: Developments in high-speed-vehicle propulsion systems (A97-15029, 02-07), Reston, VA, American Institute of Aeronautics and Astronautics, Inc. (Progress in Astronautics and Aeronautics. Vol. 165), 1996, p.421-472.
3. Development of a fuel injection system for a high frequency pulse detonation engine Lo, P. P.; Gonzalez, D. E. (Texas, Univ., Arlington) AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit, 33rd, Seattle, WA, July 6-9, 1997, 8 p. Jul. 1997 6 REFS. REPORT NO. AIAA Paper 97-2744.

KEYWORDS: Wave, Pulse, Engine, Rocket, Pulsed, Detonation, Aeropropulsion

AF99-218 TITLE: Nanoreinforced Plastics for Liquid Rocket Engine Components

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Application of nanoreinforced plastics for use as light weight materials for liquid rocket engines.

DESCRIPTION: Despite their high strength and light weight polymeric materials have made few in-roads into liquid rocket engines (LRE) component applications. Under the Department of Defense's Integrated High-Payoff Rocket Propulsion Technology (IHPRPT) initiative, an increase in the thrust-to-weight ratio of 60% is sought to meet Phase II program goals. While LRE's would obviously benefit from the weight savings of plastics, severe service requirements have restricted their use. Nanoreinforcement of plastics shows promise as a technology that is capable of increasing performance of existing resins to the point where they may have use in LRE's as ducting, turbine seals, shrouds, and nozzle extensions. These materials must operate over a temperature range of -200 C to 200 C, show o,ood wear resistance and have a high heat distortion temperature. In addition, these materials must be amenable to low cost manufacturing techniques.

PHASE I: Identify and synthesize nanoreinforced resin candidates for LRE ducting, seals, or nozzle extensions. Conduct sufficient testing to demonstrate the viability of the candidate materials for their specific application.

PHASE II: Optimize the material properties and demonstrate the ability to produce kilogram quantities of promising candidate materials at a reasonable cost and to fabricate components using conventional plastics manufacturing techniques. Provide test specimens with size and shape specific to AFRL's sub-scale component testing requirements.

PHASE III DUAL USE APPLICATIONS: Nanoreinforced plastics have great potential for use in the automotive, aircraft, electronics, and sports equipment industries wherever increased mechanical properties and higher use temperatures are I required.

REFERENCES:
1. "Property Enhancements of Common Thermoplastics via Incorporation of Silicon Based Monomers: Polyhedral Oligomeric Silsesquioxane Macromers and Polymers," J. J. Schwab, T. S. Haddad, J. D. Lichtenhan, P. T. Mather, K. P. Chaffee, in Proceedings of the Society of Plastics Engineers, 54th ANTEC, 1997, vol. 61 1, pp. 1817-1820.
2. "Nanocomposites: A Revolutionary New Flame Retardant Approach," J. W. Gilman, T. Kashiwagi, J. D. Lichtenhan, SAMPE, 1997, 3 3, 40-46.

KEYWORDS: Ducts, Shrouds, Plastic, Polymer, Turbine seals, Nanocomposite, Nozzle extensions, Liquid rocket engine

AF99-219 TITLE: Optical Measurements in Opaque Media: Combustion Applications

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop a prototype instrument to measure the properties of optically dense combustion flows.

DESCRIPTION: Many propulsion applications of interest to the Air Force involve chemically reacting flows which are too dense for conventional optical measurement techniques. Optical obscuration can be caused, for example, by turbulence/temperature interactions that cause a large random index of refraction variations, by dense sprays that are created at elevated pressures, or by large soot radiation signatures that tend to obscure the signal of interest.

This topic seeks to take advantage of innovative new techniques that have recently been developed to perform optical diagnostics in opaque or turbid media. For instance, resonant imaging holography has been performed by tuning the light source to a resonant line of the structure to be imaged and subtracting out the non-resonant signal. Structures have been visualized inside containers of milk in this way. As another example, ballistic imaging techniques have been developed which take advantage of recent fast lasers and fast detectors, where the time of photon arrival can be correlated with the number of scattering encounters. Images have been obtained through 5mm of flesh is this latter case.

Creative ideas are sought for applying techniques including, but not limited to, these examples to optically dense combustion flows. Adapting these techniques to the special requirements of combustion is expected to require its own significant degree of innovation. Techniques are sought which are capable of measuring one or more of the following quantities: temperatures, combustion species, velocities, particle sizes, and various ratios of these quantities such as O/F ratios.

PHASE I: Should identify and demonstrate the feasibility of an innovative technique for performing a combustion measurement in an optically dense flow.

PHASE II:Should develop the concept(s) identified in Phase I into a workable prototype instrument.

PHASE III DUAL USE APPLICATIONS: Optical techniques for opaque media already have vast commercial applications. Two examples are medical imaging and airport luggage scanners. Adding the capability to perform measurements in chemically reacting flows would add a large additional market. The instrument developed under this topic would have widespread commercial combustion applications not limited to military air breathing or rocket propulsion. Examples include automotive gasoline and diesel engines, gas turbine combustors for land, sea, and air applications, fossil fueled furnaces of all types, hazardous waste incineration, other non-combustion applications involving particulate flows, and a wide range of chemical process industry applications.

REFERENCES:
1. J.G. Fujimoto, editor, "Special Issue: Time-Resolved Imaging & Diaunostics in Medicine," Optics & Photonics News, Vol. 4, No. 10, (1993).
2. E.N. Leith, C. Chen, H. Chen, Y. Chen, J. Lopez, and P.-C. Sun, "Imaging through scattering media using spatial incoherence techniques," Optics Letters, Vol. 16, No. 23, 1820-1822, (1991).
3. E. Leith, H. Chen, Y. Chen, D. Dilworth, J. Lopez, R. Masri, J. Rudd, and J. Viadmanis, "Electronic holography and speckle methods for ima-ing through tissue using femtosecond gated pulses," Applied D
Optics, Vol. 30, No. 29, 4204-4210, (1991).

KEYWORDS: Combustion, Turbid media, Opaque media, Ballistic imaging, Optical Measurements, Resonant image holography

AF99-220 TITLE: Combustion Efficiency Measurements for Advanced Propulsion Systems

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop innovative strategies for measuring the combustion efficiency of advanced propulsion systems.

DESCRIPTION: A number of key performance parameters must be considered to evaluate the potential of advanced propulsion systems such as the pulsed detonation engine (PDE). Among these parameters are the fuel-air ratio, emissions indices, and combustion efficiency. Unfortunately the strategies currently in place for the determination of these parameters are inadequate for characterizing system performance. Combustion efficiency is a particularly difficult parameter to quantify for these advanced propulsion systems. Combustion efficiency is defined by the ratio of the energy released during the combustion process to the energy that would be realized were all the carbon in the fuel converted to carbon dioxide and all the hydrogen in the fuel converted to water vapor. Through measurements of carbon monoxide (CO), carbon dioxide (CO2), total hydrocarbons (HC), and oxides of nitrogen (NOx) in the engine exhaust, combustion efficiency can be calculated on an enthalpy basis by accounting for inefficiencies due to the production of carbon monoxide and unburned hydrocarbons. Measurements are typically achieved through gas-sampling systems that employ flame-ionization, infrared-absorption, or chemiluminescent detection schemes. Unburned hydrocarbons are treated as methane, and probe-based measurements are averaged over time at numerous locations in the engine exit plane to account for temporal and spatial inhomogeneities.

While this approach provides acceptable combustion efficiency measurements for current stateof-the-art gas turbine engines, advanced propulsion systems now under development are not adequately characterized through this measurement scheme. A number of specific measurement challenges exist. Advanced combustion efficiency measurements must address the many chemical forms assumed by unburned and partially burned hydrocarbons in the engine exhaust. Simply considering these emissions in terms of methane leads to unacceptable efficiency measurements. Pulsed detonation engines involve cyclical operation at frequencies up to several hundred cycles per second. This transient behavior demands innovative approaches to combustion efficiency measurement. Spatial inhomogeneities at the exit plane must also be addressed to achieve meaningful measurements. As engine operating temperatures approach stoichiometric conditions, dissociation processes and equilibrium concentrations of hydrogen and carbon monoxide in the engine exhaust must be considered as well. Often the exhaust constituents to be determined are present at trace concentrations demanding highly sensitive measurement techniques. This topic seeks the development of innovative strategies for achieving combustion efficiency measurements in light of these complications.

PHASE I: Conduct research to identify strategies that provide improved measurements of combustion efficiency compared to existing state-of-the-art approaches. Once strategies are identified, perform reduced-scale laboratory experiments to explore the advantages of the proposed measurement concepts. Modeling and other computational support of proposed strategies are advantageous but not sufficient for a Phase I effort.

PHASE II:Provide complete demonstration and documentation of the performance gains associated with the proposed strategy for measuring combustion efficiency. Ideally, this demonstration should be achieved in conjunction with a combustion application of interest to the Air Force.

PHASE III DUAL USE APPLICATIONS: Combustion efficiency measurements are critical to the development of high-performance/low-emissions engines. Technologies achieved in response to this SBIR topic will have widespread applications throughout both the military and commercial propulsion industries. In addition, the fruits of this effort will impact other combustion-related endeavors including the automotive, power-generation, and wasteincineration industries.

REFERENCE: Society for Automotive Engineers Aerospace Recommended Practices 1533, "Procedure for the Calculation of Gaseous Emissions from Aircraft Turbine Engines."

KEYWORDS: Emissions, Combustion, Propulsion, Measurement, Turbine Engines, Combustion Efficiency

AF99-221 TITLE: High Heat Sink Jet Fuels, Additives and Test Methods; Chemically Reacting Fuels

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop advanced high heat sink thermally stable jet fuels, additives, improved test methods and high temperature fuel system components. Develop chemically reacting fuels which feature enhanced properties which are activated during discrete portions of the operational envelope.

DESCRIPTION: Jet fuel is a primary coolant used to cool aircraft and engine subsystems on current and future aircraft. Current jet fuels (JP-8, JP-5) break down at high temperatures to form gums, varnishes and coke that can plug fuel nozzles, afterburner sprayrings and spraybars, fuel manifolds and fuel controls. Advanced propulsion concepts can require up to 1500 Btu/lb cooling from the fuel. To provide the necessary cooling the fuel must be resistant to degradation under both autoxidative and pyrolytic conditions and may be under supercritical or controlled cracking conditions (endothermic type fuels). In order to develop advanced high heat sink fuels, new fuel additives that suppress autoxidation and pyrolysis at temperatures as high as 450 Degrees C need to be developed. New test methods are needed to simulate the behavior of fuels at supercritical or cracking temperatures that can be used to determine fuel reaction chemistry, kinetics, heat transfer as well as chemical and physical properties at supercritical conditions. Advanced computational fluid dynamic models coupled with fuel degradation chemistry and advanced high temperature fuel system component simulators are required to determine the impact of fuel degradation in advanced aircraft and engine fuel systems. Jet aircraft produce chemical emissions that can be released into the atmosphere at high altitudes. Fuel additives that can be added to jet fuels in small quantities and suppress emissions need to be developed. Advanced emissions measuring techniques that can be used with research combustors to evaluate the effectiveness of these new fuel additives are also required.

The composition of aviation fuels such as conventional Jet-A and military JP fuels is determined by specifications which are primarily based upon total operational requirements. However, both commercial and operational requirements vary as a function of time throughout a given mission. The most efficient commercial and military fuels would have enhanced properties only when required. Fuel is one of the most expensive components of the operational and support budget of weapon systems, and the primary cost of operating commercial airliners and ground vehicles. Hence, maximizing the use of available feedstocks while minimize use of specialty components to provide the desired enhanced performance has the potential of making high cost "designer" fuels affordable ($1 - $1.50/gallon range). One attractive application would be additives which generate desirable free radicals such as OH, H and O which initiate chain branching combustion reactions, and hence provide a technique to reduce ignition delay, increase combustion efficiency, and reduce undesirable pollutant emissions.

Under the present program, innovative fuel additives are sought which react in the fuel system or the combustor to enhance a specific property. Examples of fuel properties requiring tailored enhancement include higher reactivity, emissions reduction characteristics, soot suppressants, improved thermal stability, enhanced heat sink, higher energy density, greater lubricity and low temperature supportability. The goals of Phase I are to identify suitable additives and demonstrate performance in a laboratory device such as a shock tube or benchtop fuel system simulator. A financial assessment to determine affordability must be considered. Analytical simulations should be used to screen potential additives, and use of the Major Shared Resource Center at Wright-Patterson Air Force Base is encouraged in order to successfully address the multi-scalar nature intrinsic to chemical processes. The goals of Phase II would be to demonstrate the performance of the additives at true operating conditions in large scale combustors or fuel system simulators, and assess implementation costs. In Phase III, the small business would be able to market the additives to the Department of Defense, and the transportation industry (airlines and commercial gasoline vendors).

PHASE I: Demonstrate the feasibility of the technology and to quantify the payoffs for both military and commercial applications.

PHASE II: Demonstrate the application of the technology, demonstrate a prototype of the technology, validate performance, and quantify payoffs for both military and commercial applications.

PHASE III DUAL USE APPLICATIONS: All technologies developed under this topic have both military and commercial jet fuel applications due to the similarities of the jet fuels (i.e. JP-8 is commercial Jet A-1 fuel with a military additive package).

REFERENCES:

1. "Deposition From High Temperature Jet Fuels," T. Edwards and J. V. Atria, ACS Petroleum Chemistry Division Preprints, Vol 40, No. 4, pp. 649-654, August 1995.

2. "High Temperature Cracking and Deposition of an n- Alkane Mixture," T. Edwards and J. V. Atria, ACS Petroleum Chemistry Division Preprints, Vol 41, No. 2, pp. 498-501, Mar 1996.

3. Heneghan, S. P., Zabarnick, S., Balla, D. R., Harrison, W. E., "JP-8+100: The Development of High Thermal Stability Jet Fuels," AIAA Paper 96-0403, Jan. 1996.

KEYWORDS: Fuels, Additives, Heat Sink, Thermal Stability, Thermal Management, Advanced Proppulsion, Chemical Reacting Fuels

AF99-222 TITLE: Advanced Instrumentation and Simulation Technology for Ramjet/Scramjet Combustors

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop instrumentation and computational fluid dynamic methods for measurement/simulation of subsonic and supersonic combusting flows.

DESCRIPTION: Obtaining accurate measurements of various flow parameters in a combusting flowfield without disturbing the flow is a difficult task. Various optical "flow" diagnostics techniques are currently under development for eventual use in the harsh environments of direct connect and free jet facilities. The need still exists for the development of new techniques to allow accurate point or field measurements of velocity, temperature, density, fuel concentration, and the consistency of the exhaust effluence in hydrocarbon and hydrogen fueled ramjet and scramjet propulsion systems. These techniques are also vital to the development of CFD simulation software. Software development requires that accurate and precise measurements be performed concurrently with and in a complimentary fashion to algorithm development and physical model validation. Shortcomings exist in the simulation of chemical kinetics, turbulence, turbulence-chemistry interaction, multi-phase flow, unsteady effects and acoustic phenomena. New robust miniature instrumentation is required to assess the performance of potential subsonic and supersonic ramjet combustors and various flow path components in free jet and direct connect facilities. In particular, the development of micro-scale high frequency sensors for measurements of wall pressure, temperature, skin friction and heat flux capable of surviving high enthalpy (up to Mach 8) flight conditions is desirable. Single- and multi-element addressable micro-opto-mechanical sensors are required for engine health monitoring and flow control. These sensors shall require minimal pre- and post-test calibration. The development of measurement techniques must coincide with the development of simulation techniques to ensure that the physical quantities needed by software developers are measured to the required level of accuracy. Simulation technology development should focus on chemical kinetics, multi-phase flow, and temporal and/or spatial resolution of the small-scale fluctuations found in 3d chemically reacting flows typical of ramjets and scramjets.

PHASE I: Develop and refine measurement techniques and instrumentation concepts in conjunction with CFD software to allow proof of concept and demonstration of relevance in representative subsonic and supersonic flows with and without heat release.

PHASE II:Develop the instrumentation and associated measurement techniques and validate the CFD software to the point where they can be used in realistic combustor temperature and pressure environments of direct connect and free jet facilities.

PHASE III DUAL USE APPLICATIONS: Potential for dual use is great. Similar if not identical instrumentation and measurement techniques are required in automotive, ground power generation, incineration, and the aerospace industries. Commercial success is, however, dependent on ensor/instrumentation durability, practicality, accuracy, and cost. There is a great market in the US and abroad for commercialization of micro sensors and optical instruments. Similarly CFD/simulation techniques developed under this topic could be marketed to the automotive, ground power generation, incineration, and the aerospace industries.

REFERENCES:

1. Parker, T.E., et al., "Optical diagnostics in Supersonic Combusting System," WL-TR-91-2101 (ADA-253 463/4(NTIS, 5285 Port Royal Rd., Springfield, VA.

2. Schetz, J.A., Billig, F.S., "Flow Field Analysis of a Scramjet Combustor with Coaxial Fuel Jet," AIAA Journal, Vol 20, pp 1268-1274, September 1982.

3. Winter, K.G., "An Outline of the Techniques Available for the Measurement of Skin Friction in Turbulent Boundary Layers," Progress in Aerospace Sciences, Vol 18, pp 11-57, 1977.

KEYWORDS: Micro-Scale Sensors, Addressable Sensors, High Frequency Sensors, Miniature Instrumentation, Ramjet/Scramjet Combustors, Micro-Optic-Mechanical Sensors

AF99-223 TITLE: Gas Turbine Engine Compression System Concepts

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Advance aerodynamic and mechanical technology of compression systems and secondary gas path systems.

DESCRIPTION: Future compression systems will be demanded to pack more performance into smaller, lighter, more affordable configurations. Advanced designs are utilizing highly loaded, low aspect ratio, complex shape airfoils in multistage configurations. However, increased loading produces larger blade wakes, resulting in significant aerodynamic and aeromechanical interactions between stages. In addition, increased loading has produced stall margin and efficiency sensitivity to blade tip clearance levels. Aerodynamic and aeromechanical design capability does not fully account for the unsteady interactions, the effects of wakes due to complex airfoil shapes, or the sensitivity to tip clearances that exist in compression systems. Advanced measurement methods that improve the understanding of these phenomena are desired. In addition, innovative concepts that exploit an understanding of these phenomena are needed to meet the demands of future compression systems. Areas of prime technical importance include: endwall, wake and secondary flows; time unsteadiness, advanced data analysis; forced response and mistuning.

Obtaining precise secondary gas path flow control will play an increasingly larger role in optimizing engine efficiency, as further gains in the major engine components become more difficult to achieve. Understanding primary and secondary gas path interactions can be critical to the performance of both. Reducing parasitic leakage and seal deterioration, while minimizing air needed for cooling, ventilation, and thrust balancing, is a significant challenge as the secondary gas path environment becomes more extreme. In addition, it is now anticipated that the cycle operating temperatures will dictate that cooled cooling air will be needed to maintain mechanical integrity in the turbine, and most likely in the compressor as well.

Innovative concepts and models leading towards precise secondary gas path flow control are desired. Areas of particular interest include primary/secondary gas path interaction, film riding seals, trenching and shrouds, innovative thrust balancing, counter-rotation, and disk pumping.

Clear paths for incorporation into advanced military engine designs and design systems must be shown for each of the technology concepts proposed. Teaming arrangements with major engine contractors are highly encouraged.

PHASE I: Phase I will result in demonstration of feasibility of the concepts for the development of advanced compression system or secondary flow system design.

PHASE II:Phase II will result in bench tested technology concepts for advanced compression system or secondary flow system design, adequately documented to be acceptable to the technical community.

PHASE III DUAL USE APPLICATIONS: The improvements gained in compression and secondary gas path system performance and efficiency are directly applicable to both military and commercial gas turbine engines.

REFERENCES:

1. Bullock, R., and Johnson, I., Aerodynamic Design of Axial-Flow Compressors, "Chapter III - Compressor Design System," NASA SP-36, 1965.

2. Puterbaugh, S.L., and Brendel, M. "Tip Clearance Flow-Shock Interaction in a Transonic Compressor Rotor," AIAA Journal of Propulsion and Power, Vol. 13, No. 1, Jan. 1997, pp. 24-30.

3. Smith, L. H., "Wake Ingestion Propulsion Benefit," Journal of Propulsion and Power, Vol. 9. No. 1 Jan-Feb. 1993, p. 74.

KEYWORDS: Fans, IHPTET, Compressors, Unsteady Flow, Clearance Flow, Measurement Techniques, Secondary Gas Path Systems, Aircraft Gas Turbine Engines

AF99-224 TITLE: Gas Turbine Engine Combustion Instability Prediction

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop a multi-dimensional computational method that can effectively resolve unsteady fluid dynamics with heat release effects

DESCRIPTION: Future high performance gas turbine engines will be designed to provide high thrust to weight operations over a wide range of operating conditions. This will require higher overall operating equivalence ratios, higher through flows and axial flow velocities, and higher inlet and exit temperatures and pressures. Combustor performance will also require improve stability over the entire operating flight envelope. The probability of having combustion driven instability in these advanced combustors are far greater than for the existing gas turbine combustors. Combustion driven instability involve fuel-air fluctuations, produce axial, tangential and radial modes of instability and could severely impact the engine performance and its structural integrity. Accurate determination of the time scales involved in dynamic instability is an important aspect for designing stable combustors that eliminate or damp the instabilities. Numerical methods to predict the onset of combustion driven instability are very helpful in passive and active combustion control. Current combustor design systems lack the capability of identifying acoustic coupling of these unsteady combustion processes.

PHASE I: Perform an in depth analysis to identify the causal physics of combustion driven acoustic resonances in gas turbine combustor environments and develop a methodology to predict the various modes of instability with combustion.

PHASE II: Implement methodology obtained in Phase I and demonstrate its effectiveness as applied to current combustion systems design practice.

PHASE III DUAL USE APPLICATIONS: The result of this technology will enable the characterization of the impact of unsteady combustion processes on the life and performance of all gas turbine engines, including those of military and commercial aircraft, and power generation.

REFERENCES:

1 . Darling, Douglas and Radhakrishnan, Krishnan: "Combustion - Acoustic Analysis for Premixed gas Turbine Combustors," AIAA 95-2470, AIAA Joint Propulsion Conference, San Diego, CA 10-12 July, 1995

2. Smith, Thomas M., and Menon, Suresh: "The Structure of Premixed Flames in Spatially Evolving Turbulent Flow," Combustion Science and technology, Vol. I 1 9, nos. 1-6, Oct 1996, pp. 77-106

KEYWORDS: IHPTET, Frequency, Heat Release, Unsteady Pressures, Multi-phase Combustion

AF99-225 TITLE: Gas Turbine Engine Turbine System Technology - Aerodynamics and Cooling

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop concepts for improving aerodynamic performance of turbine components.

DESCRIPTION: Proposals should address the development of aircraft engine turbine component technologies in the area of aerodynamics and aerodynamics test methods. A major trend in turbine components for aircraft engines is increased aerodynamic loading and reduced tip leakage flow. Efficient technology advances in these areas, improved experimental test methods and instrumentation for study state and/or short duration research facilities are also required.

PHASE I: Explore the feasibility of new concepts through development of conceptual hardware, software, or small scale testing to demonstrate the potential merits of the concept.

PHASE II: Provide detailed analytical derivations, prototype and/or hardware for full scale high speed rig testing.

PHASE III DUAL USE APPLICATIONS: Higher performance turbine engines and associated technologies will lead to more efficient, quieter and environmentally acceptable propulsion systems. Turbine technology improvements play a major role in military applications and there is great potential to transition to commercial use.

REFERENCES:
1. "Upgrading Jet Turbine Technology," Michael Valenti, Mechanical Engineering, V.117 n.2 Dec. 1995, pp 56-60.
2. "Progress Towards Understanding and Predicting Convection Heat Transfer in the Turbine Gas Path," Robert J. Simoneau and Frederick F. Simon, International Symposium on Heat Transfer in Turbomachinery, Athens, Greece, August 1992, NASA-TM-105674, (N92-26690/7) NTIS, 5285 Port Royal Rd., Springfield, VA.

KEYWORDS: IHPTET, Airfoils, Film Cooling, Aerodynamics, Computational, Heat Transfer, Fluid Dynamics, Turbine

AF99-226 TITLE: Gas Turbine Engine Control of Smart Components

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Investigate and develop the architecture, interface, and device conceptual design for control of turbine engine smart components.

DESCRIPTION: The next generation of turbine engines will employ micromechanical systems that sense and adapt to changing conditions. They are often referred to as smart systems because of the use of local processing and feedback. This contrasts with state-of-the-art (SOA) systems, which may operate open loop, or use feedback from parameters sensed at a distance, such as is done in modern engine control. Implementation of these strategies will significantly improve the performance of future engine components, such as the compressor, combustor, and turbine, including the fuel system. With smart effectors, high performance is achieved through coordination of large numbers of small sensors and actuators, rather than mechanical precision. They also are expected to provide substantial payoffs in terms of cost, weight, and volume required for a given functionality. Actuator size and power requirements are expected to decrease by a factor of 10, compared with SOA technology. Development of high temperature piezoelectric and optic materials for MEMS sensors and actuators is ongoing. However, a major concern with the development and implementation of these systems is the lack of suitable control paradigms. Investigation and development of control strategies that scale to systems with hundreds of sensors and actuators are desired. Consideration should be given to the following areas: modes of communication (including modes of propagation, signaling protocols, and interfacing) sensor and actuator architecture, energy distribution and requirements, and algorithms for processing and coordinating the synchronized operation of hundreds of actuators.

PHASE I: Investigate conceptual designs for control of a smart engine component. The control system will have an application to a realistic engine component such as a fuel valve, stationary vane, or compressor blade.

PHASE II:Design and fabricate a prototype control system based on the component and strategy investigated in the Phase I effort.

PHASE III DUAL USE APPLICATIONS: Commercialization potential for both military and commercial turbine engines.

REFERENCES: "A State Space Modeling and Control Method for Multivariable Smart Structural Systems," R. Butler, R. Vittal, Journal of Smart Materials and Structures, August 1996, Vol.5, #4.IOP (UK)

KEYWORDS: IHPTET, Sensors, Controls, Propulsion, Fuel Systems, Smart Controls

AF99-227 TITLE: Gas Turbine Engine Life Extension through Advanced Control Modes

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Investigate and develop new turbine engine control modes for turbine engine life extension.

DESCRIPTION: Recent development efforts have established the foundation of model-based control for turbine engines. In the implementation of these concepts, a simplified model (simulation) of the engine system is included in the feedback path of the control loop. Through proper adjustment, the model can be made to match the actual plant in terms of certain key parameters. Thereby, values of interest (not necessarily sensed values) can be computed by the model and made available for feedback purposes. It is believed that the theory and practice of model-based control can be extended to manage the life of engine rotating components, particularly in the core (compressor, combustor, and turbine). An important benefit of this approach is that changes to the engine and its control to accommodate a life-extending mode of operation will be relatively modest. It is anticipated that significant operational cost benefist can be achieved. Additionally, engine performance would not be affected during these modes of operation. Investigation of new engine control modes which vary the operating parameters and extend the life of the rotating machinery while meeting mission requirements are desired. Consideration should be given to the incorporation of the actual mechanical (material properties), environmental, and sensor constraints of a realistic combustor or turbine in the control design.

PHASE I: Investigate conceptual control modes for turbine engine life extension. These modes should address the life extension of the individual core components (compressor, combustor, and turbine). In addition, control modes that extend the overall life of the core should be considered.

PHASE II:Develop methodologies for the design and implementation of the life extending control modes.

PHASE III DUAL USE APPLICATIONS: The work described here would be directly transferable to commercial turbine engine applications.

REFERENCES:
1. Tracking Filter Selection and Control Mode Selection for Model-Based Control, AIAA-94-3204. S. Adibhatla and Z. Gastineau. Presented at the 30th Joint Propulsion Conference, Indianapolis, Indiana.
2. Engine Health Monitoring System for Gas Turbine Engines, Dr. Michael J. Roemer and
Dr. Neville F. Reiger, Stress Technology, Incorporated, Rochester, New York. USAF Aircraft Structural Integrity Program (ASIP) Conference, San Antonio, Texas. Printed in Conference Proceedings WL-TR-97-4055, pp. 793-806, (ADA 32755)
3. Real-Time Engine Health Monitoring and Diagnostics for Gas Turbine Engines, Michael J. Roemer and Ben Atkinson, Stress Technology, Incorporated, Rochester, New York. USAF Engine Condition Monitoring Workshop, San Diego, California.

KEYWORDS: IHPTET, Control, Materials, Model-based, Turbine engine, Life extension, Health monitoring

AF99-228 TITLE: Gas Turbine Engine Non-Intrusive Instrumentation

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop a non-intrusive surface-pressure and/or -temperature mapping technique and demonstrate it during an engine test.

DESCRIPTION: The development of electro-optical devices (charge-coupled device cameras) and fiber optic communications has enabled the development of optical pressure and temperature sensing schemes. In accordance with the Air Force's High-Cycle Fatigue (HCF) program, the ability to obtain global pressure maps of a rotating airfoil under unsteady dynamic loads are of particular interest. The pressure-sensitive paint (PSP) technique has shown great promise for such measurements in state-of-the-art fans. One technical challenge that remains is the development of advanced probes to image PSPs in an engine where optical access is very limited. Also, the desire to utilize the technique in latter compressor stages and in the turbine introduces a second technical challenge: the maximum temperature capability of PSPs.

PHASE I: To develop a state-of-the-art probe detection system to utilize the decay-time characteristics of PSPs. Initial goals would be for demonstration in an advance fan where temperatures up to 450 F are expected and frequency responses on the order of 10 kHz are required. Proposals on innovative non-intrusive surface-pressure or |temperature mapping techniques are also welcome. Under this phase the system should demonstrate the ability to acquire steady state measurements from rotating machinery and the potential to acquire transient data on the order of 10 kHz.

PHASE II:Develop and demonstrate the system ability to acquire transient surface pressures (10 kHz) from a state-of-the-art fan. The system should also show the potential to be used for higher temperatures (1300 F) and frequency responses (40KHz).

PHASE III DUAL USE APPLICATIONS: The development of a system to acquire 2D decay times (lifetime) of pressure-sensitive paints will have wide spread impact on the aerodynamic community. Such a technique will save millions by providing the required diagnostic tools to reduce the design cycle of not only engines, but aircraft and automobiles. The experimental data can be used to improve computational codes that in turn can reduce required test time in the design phase.

REFERENCES:

1. Gruber, M. R., Nejad, A. S., and Goss, L. P., "Surface Pressure Measurements in Supersonic Transverse Injection Flowfields," AIAA Paper No. 97-3254, 33rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Seattle, WA, 1997.
2. Liu, T., Johnston, R., Torgerson, S., Fleeter, S., and Sullivan, J., "Rotor Blade Pressure Measurement in a High Speed Axial Compressor using Pressure and Temperature Sensitive Paints," AIAA Paper No. 97-0162, 33rd AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, Seattle, WA, 1997.
3. Navarra, K. R., et al, "Optical Measurements of Surface Pressure and Temperature in Turbomachinery," presented at the 90th AGARD PEP Symposium on Advanced Non-Intrusive Instrumentation for Propulsion Engines, October 1997.

KEYWORDS: IHPTET, Gas turbine, Instrumentation, Chemical sensing, Optical diagnostics, Thermographic phosphors, Pressure-sensitive paint

AF99-230 TITLE: Electromagnetic Effects and Reliability of High Power/Pulsed Power Systems

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop techniques that provide protection to high power components and sub-systems from manmade and natural electromagnetic effects and increase operational reliability of such systems in both transient and steady-state modes.

DESCRIPTION: This solicitation seeks proposals with advanced and innovative concepts related to protecting aerospace high power systems from the effects of electromagnetic threats such as the short term and long term results of electromagnetic interference (EMI), electromagnetic compatibility (EMC), high intensity radiated fields (HIRF), lightning, and partial discharge/corona. The protection concepts and the technologies involved should address advanced aerospace electric power systems that are not only critical for aerospace vehicle operation but also provide high power and pulsed power for advanced weapon systems, surveillance, and countermeasures. Technology areas of interest are novel applications of electrical insulation in extreme environments: low pressure (<0.001 torr), high temperature (>600 C), low temperature (< 70K), and corona discharge effects. Diagnostics are needed to evaluate and predict insulation system performance in high EMI environments (pulsed or continuous). The special power systems that require smaller total volume will benefit from dielectrics which will operate reliably at high electric field stresses, thus enabling high voltage components and subsystems in less space. Additional technology areas of interest are development of electromagnetic shielding, capable of providing electromagnetic effects protection to components and sub-systems from the operational characteristics of high power and pulsed power systems for aerospace vehicles and protection from external electromagnetic threats, such as HIRF and lightning. Again, the proposed research should focus on providing reliability and integrity for aerospace vehicle systems that require higher power and smaller volumes than what is currently available.

PHASE I: Develop a detailed technical definition of the problem, identify a proposed solution, and demonstrate the key technologies enabling the use of that solution.

PHASE II: Concentrate on development of prototype components, subsystem demonstrations, hardware and software development.

PHASE III DUAL USE APPLICATIONS: All of the technologies developed under this topic can be transitioned to commercial aerospace vehicles and similar systems for ground vehicles and ships, as well as ground facilities.

REFERENCES:

1. More Electric Aircraft Goals, Air Force Research Laboratory Web Site, http://www.pr.wpafb.af.mil/divisions/prp/programs/mea/mea.htm
2. Proceedings, 11th IEEE International Pulsed Power Conference, Baltimore, MD, June 1997.
3. Proceedings, 10th International Symposium on High Voltage Engineering, Montreal, Canada, August 1997.
4. Proceedings, International Aerospace and Ground Conference on Lightning and Static Electricity, Williamsburg, VA, September 1995.
5. Proceedings, IEEE International Symposium on Electrical Insulation, Baltimore, MD, June 1992.

KEYWORDS: High Power, Pulsed Power, Electric Power, Electromagnetic Effects, Electromagnetic Interference, Electrical Insulation Materials

AF99-235 TITLE: Advanced Receiver Integration By Utilization Of Correlator Output

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop and evaluate innovative GPS receiver architectures with enhanced navigation accuracy and anti-jam performance.

DESCRIPTION: Current Global Positioning System (GPS) receivers utilize a tracking loop based design. Under this system, the correlator data is fed into the tracking loops where it is processed into pseudorange and delta pseudorange measurements. These tracking loops make no use of the inter-satellite statistical properties of phase, frequency, and delay processes. As a result, the system loses performance in the reference waveform alignment process. When the GPS signal power is rapidly varying, this loss is further amplified and can even lead to an Inertial Measurement Unit (IMU) bias state contamination. Also, as a result of the post loop observables, the observables are non-white. This forces the IMU update rates to be slower than GPS loop aiding rates and detracts from the coupling with an IMU. By implementing an approach to use the correlator data directly in the Kalman filter, these inherent weaknesses of the current tracking loop design should be avoided. In this effort, the contractor will develop and demonstrate a method to achieve this correlator output use in the Kalman filter directly, thus eliminating the conventional tracking loops. The contractor shall also develop a Virtual GPS Receiver Environment (VGRE), which receives perturbed RF signals from AFRL/SNAR's Antenna WaveFront Simulator (AWFS), downconverts and samples these signals to whatever frequency is specified by the algorithm, and monitors performance.

PHASE I: The contractor will develop a combined demodulation and navigation algorithm to perform the functions in the Kalman filter. The algorithm will be tested via simulation to evaluate performance improvements in jamming environments and vehicle blockage situations as well as standard trajectories.

PHASE II: The contractor will construct and evaluate a prototype system with the algorithm running in a signal tracking processor. Also, a sensitivity analysis to IMU quality will be performed along with definition of GRAM/SAASM interface. The algorithm will communicate with this host receiver's P/Y code correlator bank and demonstrate achieved performance improvements. The evaluation will be carried out with radio frequency (RF), IMU, and VGRE simulation tools provided by the contractor and the AWFS at AFRL/SNAR.

PHASE III DUAL USE APPLICATION: Correlator output utilization in the Kalman filter will drastically improve the robustness of both the military and civilian receivers to interference. As interference in the GPS frequency band increases, the need for improved resistance to jamming will become significant for all users of GPS. This technical effort will build the system to be used in Air Force platforms and a modified version for civilian use to reduce interference effects.

REFERENCES:
1. Sennott, J.W., Senffner, D., "Comparison of Continuity and Integrity Characteristics for Integrated and Decoupled Demodulation/Navigation Receivers," Proceedings ION GPS-95, September 1995.
2. Sennott, J.W., Senffner, D., "Robustness of Tightly Coupled Integrations for Real-Time Centimeter GPS Positioning," Proceedings ION GPS-97, September 1997.

KEYWORDS: Multiple Antenna, GPS Signal Tracking, Receiver Tracking Loops, Receiver Processing Algorithms, Modeling, Simulation & Analysis, Inertial Navigation/GPS Integration

AF99-236 TITLE: Evaluation And Demonstration Tools For Multi-sensor Fusion Technologies

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop automatic target recognition algorithm evaluation and demonstration tools for multi-sensor/multi-platform environments.

DESCRIPTION: In a multi-sensor and/or multi-platform environment, data from various sensors will be shared and fused. The ATR performance will depend on the quality of the individual sensor data and the accuracy of the accompanying reference information. AFRL/SN has funded algorithm development, evaluation and, flight demonstrations of sensors for both onboard and off-board information fusion scenarios. We are interested in receiving proposals in two subtopic areas: 1) on developing tools to capitalize on the information uncertainty and; 2) on developing evaluation and simulation tools to assist in the demonstration of fusion algorithms. The reference system subtopic would focus on the proper combining of sensor data to enhance the geo-location/geo-registering of information. The referencing information may include but is not limited to position, velocity, attitude, pointing data, and quality or uncertainty information about the data. Primary task would be to develop a practical means to capitalize on the information uncertainty that may or could be available from sensors and their host platforms and utilize it in the fusion/ATR process. Various laboratory experiments will determine the best means to characterize, extract, format, transmit, share, and use uncertainty information in the fusion/ATR process. The algorithm evaluation subtopic would focus on developing low-level simulations as a means to evaluate multi-sensor ATR performance, simulate fusion ATR performance in the SN laboratories, and use this information to assist in designing flight demonstrations. Tools using simulated data to show parametrically how sensor quality effects overall system performance are of interest. The contractor should investigate the use of simulated and/or hybrid data to investigate the algorithm operation over mission parameters for which measured data has not been collected. Image truthing and scoring tools which shorten algorithm evaluation timelines and increase the accuracy of performance measurement are also considered important to this effort. More advanced tools should examine system-of-system performance sensitivities to sensor and algorithm performance, to reference and geo-registration capabilities, and to problem complexity. All tools should be operable in the SNA laboratory environment.

PHASE I: The reference system subtopic should focus on trade-off analyses to determine the best means to characterize, extract, format, transmit, share, and use uncertainty information in the fusion/ATR process. The algorithm evaluation subtask should emphasize the development of truthing and scoring tools as well as the design of advanced tools or work should be focused at surveillance and fighter applications. Data from the Theater Missile Defense Eagel Smart Sensor Automatic Target Cuer (TESSA) program will be made available to the contractor.

PHASE II: Develop advanced simulation tools to include UAV and advanced fighter scenarios. These tools should also involve at least a subset of the processes of collecting, registering, combining, and identifying information from various sources for a marketable commercial application. This system or tool set could take on many different forms depending on the application(s), sensors, sources, information, and processing, which is being focused upon.

PHASE III DUAL USE APPLICATIONS: These include any process requiring correlation of information from disparate sources, each having its own degree of precision and reliability and its own approach for representing the quality of that information. Potential application areas would include those requiring immediate determination of "situation awareness" such as transportation, environmental or natural disaster monitoring.

REFERENCES:
1. Keydel, Eric R., Lee, Shung W., Moore, John T., "MSTAR Extended Operating Conditions:, A Tutorial," Proceedings of the International Society for Optical Engineering (SPIE) Vol. 2757, 1996.
2. E. Zelnio, F. Garber, L. Westerkamp, S. Worrel, J. Westerkamp, M. Jarratt, C. Deardorf, P. Ryan, "Characterization of ATR Systems", Algorithms for Synthetic Aperture Radar Imagery IV, Proc. SPIE 3070. Vol 3070.
3. T. Ross, E. Zelnio, L. Westerkamp, T. Burns, "Extensibility and other Model-Based ATR evaluation Concepts", Algorithms for Synthetic Aperture Radar Imagery IV, Proc. SPIE 3070. Vol 3070.
4. Berning S., Howe P., Jenkins,T. "Theater-wideREFERENCE Information Management", Proceedings of The National Aerospace and Electronics Conference (NAECON) 1996

KEYWORDS: Radar, Tracking, Infrared, Multi-Sensor, Modeling, Simulation And Analysis

AF99-237 TITLE: Laser And Radar Clutter Characterization

TECHNOLOGY AREA: Sensors

OBJECTIVE: Characterization methodology for Laser and Radar sensors to support
false alarm rate reduction and estimation.

DESCRIPTION: False Alarm Rate (FAR) reduction and estimation is an issue of growing importance for Automatic Target Recognition (ATR). A methodology is needed for characterizing clutter (i.e., any non-target region of an image) as part of solving both the FAR reduction and estimation problems. Proposals are sought for innovative methods of characterizing clutter from air-to-ground Laser Radar (Ladar) or Synthetic Aperture Radar (SAR) sensors. Ladar is of special interest for initial exploration of clutter characterization methodologies because of its high discrimination potential and relatively simple phenomenology. SAR is of special interest because of a substantial ATR technology base and the readily available measured and synthetic data. Proposers are encouraged to consider target sets that focus on military ground vehicles. The characterization of clutter is expected to depend on the sensor, the feature suite, and the target set of interest ("clutter" is, after all, defined as "not-target"). Challenges associated with FAR reduction include large variability in the target class images (e.g., from configuration variations or obscuration), a large number of target classes (numbers of over 100 are of interest), and clutter that may include non-target vehicles or other man-made objects. Clutter characterization could potentially contribute to FAR reduction by allowing improved discriminant functions which may depend on a relative comparison of a test image to targets and clutter. On-line clutter characterization could also be used for parameter adaptation or decision confidence adjustments to control FAR. Challenges associated with FAR estimation include large differences between the test imagery and the conditions-of-interest in terms of topology, vegetation coverage, climatic conditions, and development. The target set, the sensor, and their variability must also be considered. Another challenge is to estimate very low FARs with a limited amount of clutter data. Clutter characterization could potentially contribute to FAR estimation by enabling models of the relationship between test images (target and clutter) and the conditions-of-interest. Successful modeling could possibly allow the development of a small "canonical set" of test clutter that could be used to predict even small FARs for a given operational scenario.

PHASE I: The Phase I effort should include a thorough statement of the problem, outlines of one or more innovative approaches towards solution, and recommendations of materials and their sources (especially data) that could be used for Phase II.

PHASE II: The Phase II effort should include the exploration of the approach or approaches defined in Phase I, including demonstrations of FAR reductions and estimations in various scenarios.

PHASE III DUAL USE APPLICATION: The Dual Use potential is limited for this topic; however, clutter characterization methods could possibly benefit air or space surveillance in agricultural or law enforcement applications.

REFERENCES:
1. L. G. Clark (Goodwon) and V. G. Velten, "Image Characterization for automatic target recognition algorithm evaluations," Optical Engineering 30(2), 147-153 (Feb. 1991).
2. The Infrared & Electro-optical Handbook, Vol. 8, Emerging Systems and Technologies, Chapter 4, Automatic Target Recognition Systems, SPIE Optical Engineering Press and Infrared Information Analysis Center.
3. SAR Public Data Web Site:
http://www.mbvlab.wpafb.af.mil/public/MBVDATA/.

KEYWORDS: Radar, Laser, Tracking, Multi-Sensor, Modeling, Simulation And Analysis

AF99-238 TITLE: Space Based Targeting Technologies

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop and enhance technologies which support the advancement of space-based targeting capabilities.

DESCRIPTION: The objective of this effort is to enhance current modeling, simulation, algorithmic, and evaluation technologies supporting space-based targeting missions. The effort is broken out into two primary thrusts as described below. A proposer may choose to address one or both of the thrusts without penalty for omission of either thrust. The first challenge, Modeling and Simulation, seeks to expand the frontier of current space-based targeting capabilities by developing and demonstrating new simulation tools which will enable improved evaluation of advanced targeting algorithms. This thrust begins with the development and demonstration of techniques to enhance the fidelity and accuracy of signature data used in modeling and simulation applications. The quality of this data is a key factor for the integrity of algorithmic and evaluation research efforts in this area; improved fidelity and accuracy of signature data may increase confidence in radar tracking and end game engagement assessments. Areas to address include signature data compression techniques, monostatic and bistatic RCS. The proposer shall modify simulation tools as necessary to utilize high-fidelity RCS data and demonstrate the payoff of using enhanced fidelity signature data. These techniques should then be used to support the development of simulation tools which facilitate critical examination of advanced targeting information issues such as fusion of data from multiple platforms and tracking of dim/low observable targets. The emphasis of the simulation phase of this effort would be to formulate appropriate metrics, design and develop simulation tools and use these to examine tradeoffs for potential application. The second challenge, Unified Tracking and classification, seeks to develop robust technologies for simultaneously detecting, tracking and classifying moving targets from measurements of kinematics and signature. We are interested in model-based approaches that offer a unified framework for stochastic estimation of track and clss together, thereby exploiting the natural link that usually exists between them, e.g. through pose-induced transformations in the signature data. Typical kinematic measurements are range and range rate and/or azimuth and elevation, while typical signature measurements include radar high range resolution (HRR) profiles that are pose sensitive. Note that imaging sensors also exhibit signature to kinematic coupling that may be exploitable in a unified estimator. The estimation technology employed should be useful against both air and ground targets (including low observable targets) in multi-target/multi-sensor scenarios. A goal of this thrust is to produce results in real-time using affordable amounts of storage and comutation power. The government will support this thrust with 1) signature data sets, both real and simulated (e.g. the MSTAR collection), and 2) a simulation engine that models aircraft dynamics as well as radar and EO sensor outputs.

PHASE I: In the modeling and simulation area, Phase I effort will include design of new modeling techniques and simulation tools, formulation of evaluation metrics, and implementation of a subset of the modeling and simulation tools that are applicable to single and multi-platform space vehicles. The unified tracking and classification work will produce a tool and a simulated result adequate to show the potential for unifying track/class estimation tools that are applicable to single and multi-platform space vehicles. Major activites of this phase include modeling, simulation construction, and testing solution attributes.

PHASE II: Phase II will entail complete development of the simulation tools and utilizing them to perform studies and trade-off analyses as dictated by the monitoring agency for the modeling and simulation effort. For unified tracking and classification, the emphasis will be to further develop the chosen approach and demonstrate its usefulness and limitations on more complete and realistic data sets and scenarios. The following issues should be examined: mix of measurement types; alternatives in phenomena modeling; effects of noise and clutter; algorithm configuration. Final products will include the simulation tool and a technical report documenting the mathematical approach (math formalisms, associated models, computer algorithms), experimental results, performance evaluation, recommendations, and assessment of future directions.

PHASE III DUAL USE APPLICATIONS: This technology has potential commercial use in search, track and identification systems such as exist in applications like air traffic control and drug interdiction.

REFERENCES:
1. J. R. Layne, "Automatic target recognition and tracking filte,", National Symposium on Sensor and Data Fusion, April 1998, Marietta, GA.
2. E. Libby and P. Maybeck, "Application of sequence comparison methods to multisensor data fusion and target recognition," IEEE Aerospace and Electronic Systems, Jan 1997, 52-65.
3. S. Jacobs and J. O'Sullivan, "High-resolution radar models for joint tracking and recognition," Proceedings of the 1997 IEEE National Radar Conference, May 1997, 99-104.

KEYWORDS: Radar, Laser, Tracking, Multi-Sensor, Modeling, Simulation And Analysis

AF99-239 TITLE: Miniaturization Of Evanescent-mode Filters

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a Process for Miniaturization of Evanescent-Mode Filters.

DESCRIPTION: Very small high-Q evanescent-mode filters are made using very small capacitors in parallel with real or virtual inductors. The size of the filter is dominated by the size of the inductor. Therefore, one way to reduce overall filter size and weight is to reduce the amount of inductance required, and hence reduce the size of the inductor. In order to do this, the capacitance of the above-mentioned capacitors must increase. The OBJECTIVE of this project is to increase the capacitance of the capacitors in high-Q evanescent-mode filters by an order of magnitude (10X). In the current technology, single-layer thin ceramic substrates are commonly employed for developing capacitance within the very small evanescent-mode filters. Conductors on opposite sides of these thin substrates essentially form a parallel plate capacitor and hence the thickness of the substrate is inversely proportional to the capacitance. Commonly, the ceramic substrate material is alumina or quartz and current substrates are as thin as 0.003". The capacitors display Q values of at least 1000, or 3 to 4 times that of commercial multilayer capacitors. The capacitance of these devices can be increased by reducing the ceramic substrate thickness. The goal for this effort is to achieve an order of magnitude increase in capacitance, thereby requiring substrates of 0.0003" thickness. This capacitance is to be achieved at breakdown values consistent with the expected operating voltages. To build such substrates will require fabrication in place, perhaps using techniques such as Metal Organic Chemical Vapor Deposition (MOCVD), sputtering or some other evaporative process. Current MOCVD technology can be used to fabricate substrates with a thickness of 0.0001" but innovative build up layers to 0.0003" is thought to be possible. The payoff of increasing the capacitance by an order of magnitude would be an order of magnitude reduction in the above-mentioned inductor values and therefore a significant reduction in the size of the filters. A typical intermediate frequency (IF) filter (at approximately 1 GHz) weighs 1 to 3 ounces. The proposed improvement would result in filters weighing only 0.3 to 0.5 ounces. For a typical satellite payload with 500 EF filters, the total filter weight would reduce from 31 - 94 lbs to 9 - 16 lbs. Obviously, benefits associated with packaging would also be realized.

PHASE I: 1) Thorough knowledge of the limits of existing technologies, develop a plan for extending the process technology as necessary to accomplish an order of magnitude increase in the capacitance of capacitors using single-layer thin ceramic substrates, 2) Develop process plans and associated filter designs based upon the new process technology, 3) Simulate and predict the performance of a typical filter designed for fabrication by the new technology.

PHASE II:Complete detailed process/filter design and demonstrate the innovative process technology by the fabricating and testing of units capable of operation in the space environment.

PHASE III DUAL USE APPLICATIONS: The need for high-Q filter technology is continually driven by the ever-increasing crowding of the satellite communications spectrum. Therefore, improvements in such filters will benefit military, government, and commercial satellite industries. The weight reduction indicated above would hold true for both military and commercial satellite payloads.

REFERENCES:
1. R. V. Snyder, "Generalized cross-coupled filters using evanescent mode coupling elements," IEEE-MTT Symposium, Denver, CO, June 1997, pp. 1095-1098.
2. C. Kudsia, R. Cameron, W.C. Tang, "Innovations in microwave filters and multiplexing networks for communications satellite systems," IEEE Trans. MTT, vol. 40, June 1992, pp. 1133-1149.

KEYWORDS: RF Components, Ceramic Substrate, Filters/Multiplexers, Metallization Process, Evanescent Mode Filters, Substrate Metallization

AF99-240 TITLE: Innovative High Power Microwave/millimeterwave Device Development For Military Essential Systems

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop innovative semiconductor device technology and demonstrate concept feasibility for military essential applications, such as sensors for space-based radar.

DESCRIPTION: The research will explore revolutionary new device concepts and conduct feasibility demonstration efforts on devices with potential for robust, high frequency microwave/millimeterwave applications which can function in harsh environments. This effort will examine new devices, device concepts, and advanced semiconductor fabrication technology for high efficiency linear power amplification. The addressed environmental challenges consist of high temperature and/or high radiation. The intention of this program is to examine new device approaches. this will include new and existing devices (Heterojunction Bipolar Transistors (HBTs), Metal Semiconductor Field Effect Transistors (MESFETs), and other very high performance devices), new and existing device materials (InP, InGaP, GaN) and looking into novel fabrication method to improve power amplifier performance for applications such as phased array radar (military) and wireless local area network (commercial). Selection of the demonstration vehicles shall be based on customers' future needs and the availability of suppliers transferring these technologies from a research to a production environment. This program shall be divided into two phases. Device concepts, including material development and fabrication feasibility, shall be demonstrated during Phase I. Functional demonstration vehicles and design of potential products shall be completed at the end of Phase II. It is expected that fabrication capability of commercial and military products will be established by end of Phase II.

PHASE I: Material growth, characterization, and device development shall be completed.

PHASE II: Functional demonstration vehicles and design of potential products shall be completed, such as novel active devices and power amplifiers using those devices.

PHASE III DUAL USE APPLICATON: Commercial applications include personal telecommunications systems, wireless local area network, automobile sensors/collision avoidance system, security systems, and intelligent highway systems.

REFERENCES:
1. Y.-F. Wu, "High Al-Content AlGaN/GaN MODFET's for Ultrahigh Performance" IEEE Electron Device Letters, Vol. 19, No.2, pp 50-53, 1998
2. A.T. Ping "DC and Microwave Performance of High-Current AlGaN/GaN Heterostructure Field Effect Transistors Grown on p-Type SiC Substrates" IEEE Electron Device Letters, Vol. 19, No.2, pp 54-56, 1998

KEYWORDS: Semoconductors, Microelectronics, Integrated Circuits, Solid State Physics, Heterostructure Devices, III-V Compound Semiconductors

AF99-241 TITLE: RF Photonics For Space-based Application

TECHNOLOGY AREA: Sensors

OBJECTIVE: The USAF is seeking new ideas and technology to support the distribution of Radio Frequency (RF) signals in space-based platforms.

DESCRIPTION: This effort is directed to the development of photonic components (enabling technology) which are critical to the use of photonics in hgh dynamic range, low loss, high frequency, wideband analog fiber optic links for RF signal distribution and other applications in space-based and airborne platforms such as true time delay beam formation and beam steering subsystems in phased array antennas. Issues to be addressed are one or more of the following: (1) high efficiency conversions from RF to optical and/or optical to RF; (2) minimization of throughput losses (3) transparency of the photonic RF interconnect to the RF signal by (a) low noise, (b) high dynamic range - goal of 140 dB/Hz2/3 , (c) small size, (d) light weight, (e) reduced prime power requirements; and (4) low loss, high speed, high isolation photonic switching. Frequencies of interest range from 2.0 Mhz to 130 Ghz with emphasis at 44 Ghz, 60 Ghz, and 94 Ghz. Photonic based RF signal distribution is designed to replace metallic based low power RF signal distribution including RF antenna interconnects. Implementation of this technology can provide light weight, low loss, interference resistant - EMI (Electromagnetic Interferene), EMP (Electromagnetic Pulse), and SGEMP (Surface Generated EMP) - RF (and data) signal distribution. Devices of special concern are both broadband and narrow band high frequency, low voltage modulators with high dynamic range; high efficiency, high frequency, high dynamic range optical detectors with high power handling capability; and low loss, high speed, all optical switches. These device technologies must be capable of operation in both low and high altitude orbits in polar and in equatorial planes.

PHASE I: Provide a report and an initial laboratory technology demonstration of the proposed approach describing one of the devices addressed above.

PHASE II:Fabricate and demonstrate a device or demonstrates the technical goals of the program.

PHASE III DUAL USE APPLICATION: Reduced weight and interference for more maneuvering fuel and longer lifetime of commercial and military satellites. Applications areas include airborne platforms in the military and civilian usage along with potential applications to the cellular and personal radio communications sites.

REFERENCES:
1. W Ng, A Narayanan, R. R. Hayes, D. Persechini, D. Yap, "High Efficiency Waveguide Coupled ?= 1.3 m InXInXGa1-XAS/GaAs MSM Detector Exhibiting Large Extinction Ratios at L and X Band," IEEE Photonic Letters, vol. 5. pp. 514 - 517, May 1993.
2. W. B. Bridges, L. J. Burrows, U. V. Cummings, R. E. Johnson, F. T. Sheehy, "60 and 94 Ghz Coupled Electro-Optic Modulators." RL-TR-96-188 DTIC ADA318136. [NTIS: 5285 Port Royal Rd., Springfield, VA 22161]

KEYWORDS: Space, Lasers, Command, Control, Photonics, Communicatons, Electro-Optics, Photodetectors, Antenna Remoting, Optical Switching, RF Signal Distribution

AF99-242 TITLE: Reconfigurable Aperture For Sensing And Communication

TECHNOLOGY AREA: Sensors

OBJECTIVE: Demonstrate the feasibility of automated aperture reconfiguration to support multiple signal collection and transmission requirements.

DESCRIPTION: Electronic signal generation and processing are well established for a wide variety of military radar and radio equipment, covering wide sections of the electromagnetic spectrum. A significant difficulty for signal transmission and reception, however, is transitioning free-space signals of different wavelengths into and out of the electronics. Typically, a different antenna is needed for each different section of the electromagnetic spectrum (VHF, UHF, EHF, Microwave, Optical) to efficiently capture or broadcast signals. This leads to multiple antennas for satellites, command posts, mobile units, and weapon platforms to take advantage of multi-band sensing and communications. On aircraft and unmanned air vehicles, the numerous antennas increase drag and radar returns; both of which detract from mission performance. Proposed research would establish the feasibility of an antenna or aperture whose receiving/transmitting elements can be changed in near-real time to match a variety of operating wavelengths. Payoffs from the technology would include: lower RCS (radar cross-section) military aircraft, vehicles, and command posts; greater wavelength diversity to enhance target detection, increase data transmission, resist jamming/interference, and respond to hostile emanations; reduced logistics base for sensor, communication, intelligence, and avionics apertures.

PHASE I: Design a concept for reconfigurable antennas/apertures, and simulate key aspects of their multifunction capability.

PHASE II: Establish reconfigurable aperture parameters through laboratory breadboard experiments.

PHASE III DUAL USE APPLICATON: Large potential markets in security, industrial process control, medical diagnosis, exploration, and wireless communication.

REFERENCE: P.T. Ho, "Physically Adaptive Antennas," Technical Report RL-TR-95-150, Rome Laboratory, Griffiss AFB NY 13441, 1995. [(ADA 300 070) NTIS, 5285 Port Royal Road, Springfield, VA 22161]

KEYWORDS: Antennas, Conformal, Programmable, Semiconductor, Reconfigurable, Radio Frequency, Wavelength Agility, Electromagnetic Aperatures

AF99-243 Title: Enhancements To Near-field Antenna Measurements

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop elements and techniques to enhance the performance of near-field antenna measurement systems.

DESCRIPTlON: The measurement of satellite antenna patterns, especially after the antennas have been integrated with the satellite, is costly and time consuming. In recent years, near-field antenna measurement systems have been developed which significantly reduce costs by scanning a probe element across the antenna aperture to measure the pattern in the near-field. Both transmit and receive antennas can be tested using near-field techniques with, respectively, either a receive or transmit probe. Near-field measurements reduce the size of antenna test ranges and chambers and shorten the test time, thus, reducing costs. In spite of the early success of near-field techniques, performance is well below theoretical limits. Innovative research can be expected to improve the performance over existing near-field systems by as much as a factor of 20. Three specific high payoff areas are: 1) improvements in the gain and phase stability of flexible cable carrying the microwave signals to/from the probe, 2) improvements in the receiver sensitivity and settling time so that the rate at which measurements are taken may be increased by an order of magnitude or more and 3) improved data acquisition and processing techniques and algorithms which will speed the evaluation and display of the antenna characteristics.

PHASE I: 1) Perform analyses and trade-offs, concerning one or more of the high payoff areas, to determine the payoff that may be attained with the proposed techniques. 2) Develop preliminary designs and perforrn simulations to evaluate performance of elements selected to enhance near-field measurement systems. 3) Document results and detail a plan for prototype development/demonstration in Phase II.

PHASE II:1) Develop a working prototype the Phase I element(s) selected to enhance the performance of the near-field measurements, 2) Perform (mutually agreed) tests on the element(s) to quantify the performance improvement(s), 3) Integrate the selected element(s) with an existing near-field antenna measuring sytem and demonstrte the enhanced performance.

PHASE III DUAL USE APPLICATIONS: Improved satellite antenna measurement performance, clearly, will save costs for both military and civilian satellite systems. For military satellite systems, especially those with nulling antennas, large cost savings in the evaluation of antenna performance can be expected. Civilian systems, especially the new low orbit systems with as many as 200 satellites, each with multiple or multi-beam antennas, also will, clearly, benefit from improvements in the speed and accuracy of antenna pattern measurements.

REFERENCES:
1. Yaghjian, A. D., An Overview of Near-Field Antenna Measurements, IEEE Trans., Antennas and Propagation, Vol. AP-34, Jan. 1986.
2. Kearns, D. M., Plane-wave Scattering-matrix theory of Antennas and Antenna-Antenna Interactions, NBS Monograph 162, U.S. Government Printing Office, Washington, D. C., June 198l.
3. Johnson, R.C., et al, Compact Range Techniques and Measurements, IEEE Trans., Antennas and Propagation, Vol. AP- l7, Sept. 1969.

KEYWORDS: Phase Stability, Data Acquisition, Receiver Stability, Near-Field Testing, Antenna Measurements, Recriver Sensitivity, Satellite Communications

AF99-244 TITLE: Omnidirectional Hemispherical Phased Array Antenna

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop cost-effective large hemispherical conformal array antenna concepts with methods of analysis and synthesis of arrays for simultaneous multibeam satellite-ground link operations.

DESCRIPTION: Satellites are linked to an earth station by transmitting and receiving a microwave beam through antennas which can be phased arrays. The requirement for a horizon-to-horizon, full hemispherical coverage of this antenna could be implemented with a large (several meters), single hemispherical conformal phased array antenna. It will provide multiple links to simultaneously support several contact operations ranging from low altitude to geostationary satellites at different directions.

This would have the advantages over the conventional multiface planar phased array antenna in improved performance, less number of elements required, wide angle beam steering, efficient scheduling, and resource management. Current applications of this type of conformal array antenna are mostly small cylindrical or dome antennas. The beam is commutated around the arrays by means of a switching network which may become very complex for large antenna applications. Methods of analysis and synthesis of conformal arrays have not been developed to the same extent as the planar array antennas. Recent advancement in active antenna element and digital beam-forming technologies offers opportunities of investigating the possibility of developing cost effective large hemispherical array antennas to provide adaptive multibeam, horizon-to-horizon coverage, and multiple frequency bands for satellite control network operations. It may provide improved capabilities and reduce the overall satellite operations cost. The objective of this research is to develop low-cost hemispherical conformal phased array antenna concepts for horizon-to-horizon, simultaneous coverage of multiple satellites. Methods of analysis and synthesis of hemispherical conformal arrays shall also be formulated. Alternative concepts will be assessed in terms of their effectiveness, feasibility, and practicability.

PHASE I: Phase I activity shall include: (1) identification of general antenna requirements for supporting satellite network operations, (2) development of at least two candidate low-cost hemispherical conformal array antenna concepts supported by analysis and synthesis, (3) assessment of each candidate concept in terms of technical feasibility, application utility, operational adaptability, and economical viability, (4) identification of new technical issues relating to the practicality of specific candidate concepts, and (5) documentation of detailed conceptual designs and assessment results.

PHASE II:The Phase II activity shall include: (1) conduct of trade-off evaluation of the candidate conceptual designs to synthesize a single optimal conceptual design including multibeam control and scheduling, (2) construction of computer simulation and/or breadboard demonstration of selected antenna characteristics to support design analysis, identify key design parameters, and verify the projected capability, (3) using AF Satellite Control Network (AFSCN) as an illustrative example to develop a concept of operation employing the designed hemispherical array antenna, and evaluate the antenna's impact on the overall AFSCN performance, (4) rough estimation of the life cycle cost of the selected antenna concept within the context of APSCN application, and (5) documentation of all technical results and lessons learned from the Phase II activities and additional technology needs.

PHASE III DUAL USE APPLICATON: The antenna concept developed in this research will be applicable to both commercial and military satellite control networks. A low-cost array antenna is capable of improving commercial satellite control network performance and reducing operational cost, especially for the ones with large constellations such as IRIDIUM and Telsdesic.

REFERENCES:
1. Mailloux, R. J., "Phased Array Antenna Handbook," Artech House, 1994.
2. Samejima, S., "Phased Array Antenna Systems for Commercial Applications in Japan," 1966 IEEE International Symposium on Phased Array Systems and Technology, pp. 237-242, October 1996.
3. Kiuchi, E., "Tactical Cylindrical Active Phased Array Radar," 1966 IEEE International Symposium on Phased Array Systems and Technology, pp. 222-225, October 1996.
4. Kanno, M., Hasimura, T. and Katada, T., "Digital Beam Forming for Conformal Active Array Antenna," 1966 IEEE International Symposium on Phased Array Systems and Technology, pp. 37-40, October 1996.
5. Larson, W. J. and Wertz, J. R., "Space Mission Analysis and Design," 2nd Ed., Microcosm, Inc. and Kluwer Academic Publishers, 1993.

KEYWORDS: Digital Beam-Forming, Active Antenna Element, Satellite Control Network, Large Phased Array Antenna, Hemispherical Conformal Array, Horizon-To-Horizon Hemispherical Coverage, Multiple Simultaneous Satellite--Ground Links

AF99-245 TITLE: Smart-pixel Turbulence Aberration Correction

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a smart-pixel device to compensate for high-speed optical aberrations.

DESCRIPTION: Satellite and aircraft imaging sensors must locate, identify, and track distant objects in the presence of rapidly changing optical aberrations, such as those caused by severe atmospheric or aircraft boundary-layer turbulence. These aberrations can change on the time scale of microseconds. Adaptive optics systems cannot respond fast enough to correct such aberrations, especially in high-resolution, large field-of-view systems designed for satellites or high-altitude surveillance. A smart-pixel device can, in principle, respond much faster, provided any processing can be done in parallel. For example, light from a guide star can be reflected from a torsion mirror array then onto a Hartmann angle sensing array. The Hartmann sensor output can be used to control the torsion mirrors, creating a feedback loop that automatically flattens the wavefront at a speed limited only by the response time of the torsion mirrors. Other alternatives would be to include smart processing circuitry in each pixel to convert the Hartmann angle information into a signal to be applied to a spatial light modulator.

PHASE I: Construct a small proof-of-concept array to correct optical aberrations in at least one dimension.

PHASE II:Fabricate a 64x64 array that corrects two-dimensional optical aberrations with a response time of at least 10 microseconds. Design must be scalable up to array sizes of 256x256 without exceeding the response time limit.

PHASE III DUAL-USE APPLICATION: Commercial satellite imaging systems and ground-based telescope systems would benefit from such a device.

REFERENCE: Motamedi, M. E., et.al. "Micro-opto-electro-mechanical devices and on-chip processing," Optical Engineering 36, May 1997, pp. 1282-1297

KEYWORDS: Turbulence, Smart-pixel, Adaptive-optics, Aberration correction

AF99-246 TITLE: Unmanned Aerial Vehicle Antennas

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop concepts for structurally integrated lightweight airborne phased array antennas for Unmanned Aerial Vehicle (UAV) applications.

DESCRIPTION: Structurally integrated phased array antennas will have an important role on present and future UAV's. Arrays with wide angle multibeam agility will be used for communications in the HF to K band frequency range, for passive bistatic radar functions at S-band, for active radar functions in L-band to X-band and foliage penetration from L-band to VHF. Multifunctional and multifrequency fully populated phased arrays based on tile architectures are possible candidate solutions. Low cost, lightweight and structurally integrateable antenna concepts are required to ultimately achieve acceptable life-cycle costs for UAV's. Concepts developed under this SBIR have the potential to greatly promote a quckly growing multifaceted market.

PHASE I: 1) Perform antenna concept analyses and trade-offs, for one or more phased array applications. 2) Develop preliminary antenna performance simulations to evaluate beam and frequency coverage, multifunctionality and vehicle integration. 3) Document results and detail a plan for proof-of-concept development/demonstration in Phase II.

PHASE II: 1) Produce a comprehensive structurally integrated multifunction airborne phased array simulation to validate plausible antenna architectures. 2) Identify key sub-system antenna performance requirements. 3) In conjunction with AFRL Sensors Directorate, select crucial phased array components and produce a proof-of-concept prototypes.

PHASE III DUAL USE APPLICATIONS: Improved structurally integrated multifunction airborne phased array will bring new communication and radar functionality for both military and civilian airborne systems. For military airborne radar and communication systems a large savings in the life cycle cost for surveillance assets is expected. Civilian airborne communication systems, especially large passenger aircraft with increased demand for high communication data rates, will benefit by the lower cost of mass producible structurally integrated antennas.

REFERENCE: Proceedings of the Antenna Applications Symposium, 1995, 1996, and 1997, Allerton Park, IL.

KEYWORDS: Antennas, Pphased Array, Space Fed Lens, Constrained Feed, Structural Antennas

AF99-247 TITLE: Laser Radar For Long-range Ranging And Non-cooperative Identification

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop advanced, laser radar techniques and components for long-range, Space/Air non-cooperative identification, ranging, and tracking.

DESCRIPTION: With the advent of multi-national conflicts involving a variety of friends, foes, and non-combatants, long-range non-cooperative identification (NCID) has become an extremely important aspect of battle management. Research has shown that a variety of ladar (laser radar) modes have the potential to contribute to the long-range NCID solution from both airborne and space platforms. The limited aperture sizes dictated by platform real estate limit the useful range of spatially-resolved imaging and drive the solution to multi-function shared aperture implementations. Non-imaging, high temporal resolution ladar (1D ladar) or range-Doppler ladar (velocity or vibration sensing) promises to provide a viable solution to the long-range NCID requirement utilizing designator-class laser systems. The nature of the 1D-ladar signature is relatively range independent and should have utility well beyond the aperture limited imaging limit. Acceptable research would examine novel extended range ladar concepts and techniques. Proposed transceiver concepts should focus on providing solid-state, eye-safe NCID implementations that maximize multi-function, shared-aperture operation including at least precision range (< 30 cm resolution) and designation (> 100 mJ/pulse) capabilities. The program may examine, but is not limited to 1D pulse shape and pulse modulation techniques; extended information extraction from 1D returns; range-Doppler techniques; novel transmitter design approaches for both 1D and range Doppler; automatic target recognition; and other promising long-range optical ID concepts. All concepts should develop transmitter/receiver specifications and preliminary designs, examine wavelength optimization based on analysis atmospheric effects, and develop performance predictions based on the proposed 1D concepts and transceiver specifications.

PHASE I: Design and assess laser transmitter and receiver architectures and critical component technologies. The approach to achieving long-range target identification will be defined. Critical issues associated with the technique including transceiver designs, feasibility demonstrations of key technologies, and atmospheric propagation from both air and space-based platforms will be investigated.

PHASE II:Fabricate and quantitatively evaluate an eye-safe ladar for long-range identification technique demonstration. Critical issues associated with the technique and the associated transceiver would be addressed and fabrication approaches would be demonstrated.

PHASE III DUAL USE APPLICATION: High-resolution laser radars at eye-safe wavelengths would greatly increase the potential applications of laser radar systems. Potential commercial applications include surveying, time-of-flight imaging for medical diagnostics, ocean research, and space object imaging applications. Imaging in factories for process control, imaging for nondestructive testing, and imaging for surveillance and security are also examples where this technology can be applied.

REFERENCES:
1. F. K. Knight, D. I. Klick, D. P. Tyan-Howard, J. R. Theriault, and B. K. Tussey, "Two dimensional tomographs using range measurements," Proc. SPIE Vol. 999 (1988).
2. Sandor Der, Brian Redman, and Rama Chellappa, "Simulation of error in optical radar range measurements," Appl. Opt. 36(27) 6869-6873 (1997).
3. J. A. Overbeck, M. S. Salisbury, M. B. Mark, and E. A. Watson, "Required energy for a laser radar system incorporating a fiber amplifier or an avalanche photodiode," Appl. Opt. 34(33), 7724-7730 (1995).

KEYWORDS: Ladar, Laser, Detection, Laser Radar, Laser Ranging, Laser Doppler, Non-Cooperate Identification

AF99-248 Title: Real Time Non-mechanical Microscanning Techniques

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop new or improved techniques, algorithms or algorithm coding to accomplish real-time non-mechanical microscanning (microdithering) for infrared sensors.

DESCRIPTION: Military and commercial imaging infrared sensors are transitioning from one-dimensional linear arrays to two-dimensional staring arrays. The resolution of staring infrared imaging sensors is limited due to the optics as well as by both the physical dimensions of the detector elements in the focal plane array and the detector pitch. These sensors tend to be inherently under sampled, resulting in aliased imagery. Resolution improvement can be accomplished by reducing the effective detector pitch and increasing the sampling frequency through a technique referred to as dithering, or microscanning. Additional enhancement is possible through deconvolution of the detector and optics blurring. Microscanning involves processing a sequence of frames where the field-of-view of each frame is displaced slightly (typically subpixel) from the other frames to create a high-resolution image. Microscan motion can be induced in a controlled or uncontrolled manner using a mechanical dither mirror and/or platform motion. Common image processing elements of current algorithms include subpixel registration, image interlacing, high-resolution pixel estimation, and deconvolution. Recursive algorithms employing maximum-likelihood or maximum a posteriori estimation techniques have proven to be very effective. However, they are computationally intensive and real-time implementation on multi-processor systems is not currently possible. Faster algorithms which use gradient-based registration and simplified deconvolution hold promise for real-time implementation, but for image sizes approaching 1024 X 1024 pixels, this becomes extremely challenging. Complex nonglobal image motion and affine transformation between image frames further complicates image processing. Real-time microscanning requires improvements of 30-100 times versus the techniques used to date. Such performance improvements could be realized with better algorithms, more efficient coding tools and techniques, or specialized processing hardware.

PHASE I: Define and evaluate approaches, based on non-mechanical microscanning algorithms, coding tools, and/or techniques, to obtain real-time microscanning in infrared imaging sensors.

PHASE II: Develop, demonstrate and deliver selected concept defined during Phase I.

PHASE III DUAL USE APPLICATIONS: The ability to perform real-time microscanning has wide application in remote sensing, machine vision, and surveillance. Other general-purpose image processing also requires more efficient implementation and could benefit from better coding tools and techniques.

REFERENCES:

1. G. C. Holst, Sampling, Aliasing and Data Fidelity, JCD Publishing, Winter Park, FL, and SPIE Optical Engineering Press, Bellingham, WA,1998.
2. R. C. Hardie, K. J. Barnard, and E. A. Armstrong, "Joint MAP Registration and High-Resolution Image Estimation Using a Sequence of Undersampled Images," IEEE Transactions on Image Processing, Vol. 6, No. 12, 1621-1633, Dec. 1997.
3. R. C. Hardie, K. J. Barnard, E. A. Watson, E. A. Armstrong, "High-resolution image reconstruction from a sequence of rotated and translated frames and its application to an infrared imaging system," Optical Engineering, Vol. 37, No. 1, 247-260, Jan.1998.
4. S. Cain, R. C. Hardie, and E. Armstrong, "Restoration of aliased video sequences via a maximum-likelihood approach," in Proc. Nat. Infrared Information Symposium on Passive Sensors, Monterey, CA, Mar. 1996.
5. Muse, Blommel, et al, "Comparison of Staring vs Microscan Recognition Range," 1994 Meeting of the IRIS Specialty Group on Passive Sensors, Vol 1, Jul. 1994.

KEYWORDS: Dither, Subpixel, Infrared, Microscan, Imaging Sensors, Image Processing

AF99-249 TITLE: Multispectral Infrared Phenomenology For Combined Threat Warning And Reconnaissance Sensors

TECHNOLOGY AREA: Sensors

OBJECTIVE: Determine the feasibility of a single multispectral infrared sensor capable of missile threat warning and ground target detection.

DESCRIPTION: Proposed solutions for missile threat warning and subpixel detection of ground-based targets indicate differences of band / subband selection and angular field of view (FOV) / field of regard (FOR). A common sensor or even common modules, if achievable, would have substantial payoff for the military and commercial markets for ground, air, and space applications. For both functions, multicolor IR has been shown to provide excellent clutter rejection for specific band combinations. The missile threat warning sensor must detect the presence of a threat in a cluttered environment, on short time lines, with a minimum number of false alarms. For this function, the desire to detect missile plumes with minimum background contribution has driven multicolor designs to the Mid-IR spectrum. For multispectral or hyperspectral sensors in surveillance or reconnaissance applications, target detectability is enhanced by exploiting spectral features which have large separation from the highly correlated background for certain spectral combinations. For subpixel target detection, spectral mixing of target and background features must be accounted for. Presently, the optimum bands (and number of bands) for this function is not well understood and is often generalized from specific field scenarios. Initial indications are that LWIR subbands provide more robust discrimination. Increased demand for compact, affordable IR sensors makes the combination of these two, seemingly incompatible functions, highly desirable. Since cost is a major concern, a single sensor either in just the midwave, or one capable of both midwave and long wave subbands would be highly desirable, even if different front end optics had to be used for each application, due to FOR issues.

PHASE I: Investigate spectral properties to enable detection of tactical missiles, theater missiles, and ground targets, to include deep-hide, camouflaged, and concealed targets. Background clutter effects for various terrain and climate scenarios must be considered. For missile threat warning, low false alarm rates over a WFOR must be a constraint. For subpixel target detection, spectral mixing effects at long range must be considered. Phase I will conclude with identification of candidate bands / subbands and a definition of a preliminary sensor design, or sensor module designs.

PHASE II:Validate spectral band optimization through a series of simulations over a broad range of targets and backgrounds. Fabricate a breadboard sensor with sufficient portability to conduct a variety of tower and field measurements. Different optical front ends may be used for each application, if required.

PHASE III DUAL USE APPLICATION: Numerous non-military markets which exploit thermal measurements benefit from this development. The common-mode sensor has concurrent applicability for intrusion detection, collision warning, oil and mineral exploitation, and environmental monitoring.

REFERENCES:

1. Erdman, Carey D., Robert L. Huguenin, and Lawrence A. Scarff, "Utilizing subpixel identification schemes to address emerging application areas," Proc. SPIE 3119, 196-204 (9/1997)

2. Goetz, Alexander F., Bruce Kindel and Joseph W. Boardman, "Subpixel target detection in HYDICE data from Cuprite, Nevada," Proc. SPIE 2819, 7-14 (11/1996)
3. Sanderson, R. B., "Infrared Missile Warning Sensors", Proceeding fron the Nat'l Aerospace & Electronics Conference, Dayton OH, Jul 96

KEYWORDS: Imaging, Thermal, Subpixel, Infrared, Detection, Hyperspectral, Multispectral, Classification, Spectral Mixing, Missile Warning

AF99-250 TITLE: Modular, Multi-discriminanat Electro-optical Sensors-munitions To Satellites

TECHNOLOGY AREA: Sensors

OBJECTIVE: Design a multi-discriminant electro-optical (EO) sensor architecture which can be scaled from a core sensor module to an n-module system and can be hosted on platforms ranging from munitions to satellites.

DESCRIPTION: The capability exists today to develop EO sensors which can sample and process a variety of target discriminants such as 3-D spatial, spectral, thermal, vibration, polarization, etc. Increasing the number of sensed discriminants often increases confidence for target detection, tracking, identification, engagement, and damage assessment. The number of discriminants to be sensed must be traded between target difficulty and host platform volume/cost constraints. Developing federated sensors suitable for the broad range of target tasks and host platforms is financially prohibitive. Recently there has been increased emphasis in developing multi-function EO sensors; for example, sensors which can sample 3-D spatial features via laser radar as well as additional discriminants, such as micro-Doppler for vibration sensing. The need exists for a sensor architecture which can start with a core sensor module and be scaled up, in a modular sense, as the need for additional discriminants is mandated. The core sensor would be designed for a low-cost smart munition, hence, could presumably be a short-range laser radar sensor. A more basic core sensor might be designed for the automotive industry, thus, motivating a very high-volume, low-cost core. As the host changes to manned and unmanned aircraft or space platforms, and the mission mandates additional discriminants, the core sensor would be scaled by additional discriminant modules. Power scaling of a laser source should also be considered. Analogous to the sensor modules, this effort will identify core processing requirements, scalable in a modular sense to accommodate increased discriminant processing.

PHASE I:Identify a core sensor and processing architecture suitable for a low-cost smart munition; e.g., laser radar seeker. A more basic module for an automobile proximity and collision warning sensor would be desirable from a cost standpoint, which in turn would be scaled to a munition package. The core design should include an "expansion" capability for adding additional discriminants. Candidates to be considered may be active, passive, or a combination and will be collaboratively finalized by the government and small business principal investigators in the early part of Phase I. The intent of Phase I is to determine if modular EO sensors can be realizable and scalable for a large number of missions and platforms; hence, a phenomenological prioritization of discriminants is not required for this topic.

PHASE II:From a core sensor and a discrete set of additional discriminant modules, fabricate a breadboard sensor with sufficient portability to perform a variety of tower and field measurements.

PHASE III DUAL USE APPLICATION: A core laser radar module in a low-cost package has applicability for an automobile collision warning system as well as a host of commercial terrain mapping and natural resource management systems. A modular, scalable package could be employed in a variety of airborne and space vehicles for weather profiling, crop reporting, etc.

REFERENCES:
1. Paul F. McManamon, Edward A. Watson, Michael T.Eismann,"Suggestions for Low Cost Multifunction Sensing", IEEE Aerospace Conference, Military Avionics Session, Snowmass, CO, April 1998
2. Johnson, J., "Analysis of Image Forming Systems," Proceedings of Image Intensifier Symposium, AD 220 160, US Army research and Development Lab, Ft. Belvoir, VA (1958) pp 249-273.

KEYWORDS: Ladar, Sensors, Modular, Munitions, Laser Radar, Multifunction, Remote Sensing, Electrol-Optical, Multi-Discriminant

AF99-251 TITLE: Global Positioning System (Gps) Receiver Antenna For Spinning Satellite

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a spaceborne antenna for use onboard a spinning satellite to track all-in-view GPS satellites.

DESCRIPTION: There is a global need for satellite position determination (during launch and in orbit) for both government and commercial satellites. The Air Force has specific requirements for satellite position determination. The position of a satellite during launch is currently tracked by ground monitor stations using an S-Band signal. Sometimes, the reliability of the tracking data is in question. The launch and on orbit position of a satellite could also be determined by a GPS receiver onboard the satellite that can continuously track all-in-view GPS Satellites. The Position information could then be down linked to the ground monitor stations for position determination. During launch and in orbit, the satellite could be spinning at up to 60 revolutions per minute and its attitude also changing: therefore, the type of receiver antenna and the location of the antenna onboard the satellite should be examined to ensure that it can track all-in-view GPS satellites continuously. At a minimum, the following issues should be addressed: 1. Antenna location, 2. Antenna pattern (a broad beam pattern to meet the beamwidth and to give a gain level above a specified requirement for the field-of-view), 3. Antenna gain (the gain can not be constant but will roll off. This gain roll off should be gradual and smooth with a ripple not to exceed a certain level. This gain ripple will be caused by factors such as multipath, blockage, and the switching between antenna elements in the array), 4. Antenna beam efficiency, 5. Antenna polarization purity, 6. Antenna tuning (The antenna will be tuned to center frequency and should not be allowed to drift or detune outside of a specified range), 7. Voltage Standing Wave Ratio, 8. Insertion loss and isolation between elements, and 9. Surviving environmental factors such as extreme heat, thermal cycling and vibration.

PHASE I: Effort will include: 1. Develop a candidate antenna design to meet the intended requirement, 2. Government input will provide target values for the above requirements/variables, 3. Provide design documentation that provides proof of design concept, and 4. Demonstration of (mutually agreed) key technology elements of the chosen antenna design.

PHASE II: 1. Complete detailed design of the candidate antenna, 2. Build and demonstrate a prototype of the final antenna design in concert with an appropriate GPS Receiver.

PHASE III DUAL USE APPLICATION: This antenna technology can be sued for GPS tracking of commercial satellites during launch and at all orbital altitudes.

REFERENCE: Global Positioning System: Theory and Applications Volume 1, Edited by Bradford W. Parkinson, James J. Spiker Jr., Published by: The American Institute of Astronautics and Aeronautics (AIAA)

KEYWORDS: S-Band Signal, Satellite Antenna, Orbit Determination, Position Determination, Space-Based GPS Antenna, Global Positioning System

AF99-253 TITLE: Global Positioning System Advanced Controlled Reception Pattern Antenna And Electronics

TECHNOLOGY AREA: Sensors

OBJECTIVE: Design, and develop a Controlled Reception Pattern Antenna that reduces interference and multi-path by adaptive cancellation.

DESCRIPTION: The cellular phone industry has spent millions of dollars to reduce the effects of multi-path and interference in very highly cluttered environments. The cellular phone industry has millions of users that require low cost lightweight solutions. These low cost lightweight solutions could also benefit the Global Positioning System in the reduction of jamming, multi-path or unintentional interference. The current Controlled reception pattern antenna uses a seven-element array. The cost of the current array and electronics is over $25,000. The goal of this program is to reduce the system cost (antenna, electronics and software) to less than $10,000. The system is required to null six broadband interference sources Additional areas of interest are true time delay beam and null steering for a low cost implementation of a Controlled Reception Pattern Antenna.

PHASE I: 1.) Investigate a candidate antenna configuration, 2.) Determine the optimum antenna pattern given the satellite orbits and receiver considerations and the location of potential interference. Calculate improved antenna performance and antenna gain patterns.

PHASE II: Fabricate a candidate advanced controlled Reception Pattern Antenna and test in the presence of multiple noise sources in an anechoic chamber or an outdoor test range.

PHASE III DUAL USE APPLICATION: GPS receivers used in urban environments for survey equipment and vehicle location tracking often have problems with interference from ground based sources. These commercial users could benefit from a Controlled Reception Pattern Antenna with low cost interference suppression.

REFERENCE:

1. Guttrich, Sievers and Tomljanovich, "Wide Area Surveillance Concepts Based on Geosynchronous Illumination and Bistatic Unmanned Airborne Vehicles or Satellite Reception." The MITRE Corp., 1997.
2. "Space-Time Adaptive Processing for Advanced Airborne Surveillance (AAS) Bistatic Radar," Sanyal and Melvin, MITRE & USAF Rome lab June 1997
3. 1997 IEEE Aerospace Conference, Aspen, CO, Feb. 1-8, 1997, Proceedings. Vol. 2 (A97-44051 12-99), Piscataway, NJ, Institute of Electrical and Electronics Engineers, Inc., 1997, p. 171-180.

KEYWORDS: Antenna, Low Cost, Anti-Jam, Fixed Antenna Pattern, Interference Reduction, Global Positioning System

AF99-255 TITLE: Real-time Multi-spectral Synthetic Battlespace

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop real-time multi-spectral synthetic battlespace environment simulations for developing/transitioning advanced airborne/space sensor technologies.

DESCRIPTION: Man/hardware-in-the-loop laboratory simulation is the most cost-effective evaluation methodology for maturing advanced sensor technologies because the battlefield can be brought to the laboratory through multispectral synthetic battlespace simulation. Multispectral synthetic battlespace simulation provides precise control of the test conditions which enables the advanced sensor technologies to be subjected to multiple realistic combat situations making it possible to identify/resolve technology issues before ever flying or fielding the capability. It is a critical step that significantly reduces the time, risk and especially cost associated with transitioning advanced sensor technologies. These advanced sensor technologies provide a multispectral view that is integrated through information processing for a highly accurate assessment of the battlefield situation for the warfighter. Current laboratory simulation technologies cannot generate the real-time high fidelity multispectral environment required for conducting realistic advanced technology demonstrations.

PHASE I: Identify innovative real-time simulation technologies that enable multi-spectral synthetic battlespace environment generation for the development, demonstration, and transition of advanced sensor technologies for airborne/space applications. The Phase I research will identify the critical simulation technology challenges and define the Phase II approach for developing/demonstrating the critical simulation technology required for real-time multi-spectral synthetic battlespace environment generation in the Sensors Directorate Integrated Demonstrations and Applications Laboratory (IDAL). Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE II: Implement and demonstrate the critical real-time multi-spectral synthetic battlespace environment generation simulation technology in the Sensors Directorate Integrated Demonstrations and Applications Laboratory (IDAL).

PHASE III DUAL USE APPLICATION: Multi-spectral synthetic battlespace environment generation simulation technology is a dual-use technology that has extensive commercial applications for markets such as the security protection and airline industries. This simulation technology can be utilized to develop information processes that fuse data from multi-spectral sensors to provide highly accurate real-time situation assessments for the commercial security protection market. This simulation technology can also be utilized to develop and evaluate low visibility aircraft landing system concepts involving multi-spectral imaging systems. This simulation technology will reduce development costs and accelerate product movement to the market place.

REFERENCE: McQuay, W. K., "J-MASS and Concurrent Simulation in the Laboratory Environment," p585-7. Proceedings of IEEE NAECON '96, National Aerospace and Electronics Conference, 1996. A96-37576.

KEYWORDS: Sensors, Real-Time, Synthetic, Simulation, Battlespace, Multi-Spectral

AF99-256 TITLE: "System Of Systems" Network Centric Sensors Demonstration Testbed

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop "system of systems" technology demonstration/application testbed for evolving advanced network centric concepts.

DESCRIPTION: Joint Vision 2010 (JV2010) utilizes operational concepts of Dominant Maneuver, Precision Engagement, Focused Logistics and Full Dimensional Protection with Information Superiority for joint warfighting. One of the key challenges in this vision is understanding how advanced sensors combined with Information Superiority can be exploited for a "system of systems" approach that provides "networks" of sensors, command and control, and shooters to enable "Network-

Centric Warfare." This type of capability will be applied to the next generation aircraft such as the Joint Strike Fighter (JSF) to provide the ability to delay detection by our adversaries by reducing its radar, infrared, and emissions signature through a SoS approach that retains a high degree of accuracy, lethality, survivability and mission flexibility. The Sensors Directorate Integrated Demonstrations and Applications Laboratory (IDAL) is evolving advanced sensor and information processing technologies through collaborative engineering environments where the IDAL sensor testbeds are linked to other government/industry research facilities to form a collaborative advanced technology demonstration capability.

PHASE I: Identify innovative real-time simulation technologies required for an IDAL "system of systems" technology demonstration/application testbed for evolving advanced network centric concepts involving both airborne and space sensor assets. The Phase I research will identify the critical simulation technology challenges and define the Phase II approach for developing/demonstrating the critical simulation technology required for a "system of systems" network centric sensors demonstration testbed in the Sensors Directorate Integrated Demonstrations and Applications Laboratory (IDAL). Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE II: Implement and demonstrate the critical "system of systems" network centric sensors demonstration testbed simulation technology in the Sensors Directorate Integrated Demonstrations and Applications Laboratory (IDAL).

PHASE III DUAL USE APPLICATION: Network centric simulation technology is a dual-use technology that has extensive commercial applications for markets such as the computer and communication industries. This simulation technology can be utilized to develop parallel information processes for computer implementation that enhance current commercial computers. This simulation technology can also be utilized to develop communications networks that can address the growing marketplace need for enhanced information processing.

REFERENCE:

1. McQuay, W. K., "J-MASS and Concurrent Simulation in the Laboratory Environment," p585-7. Proceedings of IEEE NAECON '96, National Aerospace and Electronics Conference, 1996. A96-37576.
2. INFORMATION PAPER: Obervations of the Emergence of Network-Centric Warfare.
http://www.dtic.mil/jcs/j6/education/warfare.html.

KEYWORDS: Sensors, Testbed, Simulation, Demonstration, Network Centric, System of Systems

AF99-257 TITLE: Air Target Combat Identification Technologies

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop new and innovative techniques for Combat Identification of air targets.

DESCRIPTION: The Air Force is actively pursuing Combat Identification (CID) capabilities for use in modern fighter aircraft and from space-based platforms. Current capabilities are not robust and require significant pilot attention for positive CID. The Vincennes Disaster, Desert Storm, and Operation Deny Flight have demonstrated the critical need to positively identify air targets. The destruction of hostile air targets while preserving non-combatant, neutral, and friendly aircraft remains a top priority. Identification must positively declare aircraft type to enable high-confidence engagement decisions. Class level declarations, whether cooperative or non-cooperative, may be considered viable components of a type level CID system of systems. One primary sensor for CID is radar with emphases on airborne tactical radar systems and space-based systems. These systems allow the active or passive collection of multi-mode electromagnetic data which might prove suitable for CID exploitation. CID of air targets is currently performed by signature pattern matching or by performing specialized processing to the radar signature. Other target information in the returned radar signal that is ignored or lost due to advanced processing may provide additional features and characteristics improving overall CID. Since there are no predefined sets of exploitable electromagnetic features that uniquely describe targets under all conditions, processes that can yield a robust, high-confidence feature/capability for discrimination should be examined under this research topic. For example, such processes may include radar signature information with complex vibratory or target feature inter-relationships.

PHASE I: Investigate and identify features, characteristics, and innovative informational relationships for target identification. Based upon these results, develop concepts for signature exploitation, CID algorithm designs, and performance evaluation.

PHASE II:Develop and demonstrate the signature exploitation CID algorithm.

PHASE III DUAL USE APPLICATION: Advances in target identification has applications in drug interdiction, air traffic control, industrial inspection, and manufacturing automation.

REFERENCE: Cranos, Roger, "Combat Identification in the Future: Maintaining a Balance," presented at the Society of Photo-Optical Instrumentation Engineers (SPIE) 11th Annual International Symposium on Aerospace/Defense Sensing, Simulation and Controls, 20-25 April 1997.

KEYWORDS: Radar, Lasers, Infrared, Signal Processing, Target Recognition, Combat Identification

AF99-258 TITLE: Surface Target Combat Identification Technologies

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop new and innovative techniques for Combat Identification of surface targets.

DESCRIPTION: The Air Force is actively pursuing Combat Identification (CID) capabilities for use in modern fighter aircraft and from space-based platforms. Current capabilities are not robust and require significant pilot attention for positive CID. Desert Storm demonstrated the critical need to positively identify surface targets. The destruction of hostile surface targets while preserving non-combatant, neutral, and friendly vehicles remains a top priority. Identification must positively declare vehicle type to enable high-confidence engagement decisions. Class level declarations, whether cooperative or non-cooperative, may be considered viable components of a type level CID system of systems.

One primary sensor for CID is radar with emphases on airborne tactical radar systems and space-based systems. These systems allow the active or passive collection of multi-mode electromagnetic data which might prove suitable for CID exploitation. Programs exist that provide algorithms and data for stationary ground target location and ID (i.e.; Moving and Stationary Target Acquisition and Recognition (MSTAR) program) and that provide high range resolution algorithms and techniques for detection of ground moving targets (i.e.; System High Range Resolution A/G Recognition (SHARP) and Moving Target Exploitation (MTE) technology development programs). Since there are no predefined sets of exploitable electromagnetic features that uniquely describe targets under all conditions, processes that can yield a robust, high-confidence feature/capability for discrimination should be examined under this research topic. For example, such processes may include radar signature information with complex vibratory or target feature inter-relationships.

PHASE I: Investigate and identify features, characteristics, and innovative informational relationships for target identification. Based upon these results, develop concepts for radar signature exploitation, CID algorithm designs, and performance evaluation.

PHASE II: Develop the radar signature exploitation CID algorithm.

PHASE III DUAL-USE APPLICATION: Advances in target identification has applications in drug interdiction, vehicle/container control and tracking, industrial inspection, and manufacturing automation.

REFERENCE: Cranos, Roger, "Combat Identification in the Future: Maintaining a Balance," presented at the Society of Photo-Optical Instrumentation Engineers (SPIE) 11th Annual International Symposium on Aerospace/Defense Sensing, Simulation and Controls, 20-25 April 1997.

KEYWORDS: Radar, Lasers, Infrared, Signal Processing, Target Recognition, Combat Identification

AF99-259 TITLE: Innovative Planning Tool For Urban Electromagnetic Environment Characterization

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop techniques and tools to accurately characterize and manage electromagnetic environments in urban areas for improved performance of Air Force sensor and communication systems.

DESCRIPTION: The Air Force must acquire the capability to accurately characterize and predict urban electromagnetic environments at all potential operating frequencies used by present and future sensors and communication systems. The research of sample opearating scenarios will include the parametric characterization of urban clutter phenomenology for space-based and airborne radar systems, and the estimation of signal interference and attenuation for battlefield wireless networks. The databases of high-resolution digital terrain maps collected by the National Imagery and Mapping Agency (NIMA) and other agencies enable the construction of high-fidelity CAD models of urban areas including natural and manmade structures such as parks, buildings, roads and bridges. These CAD models can be used to perform accurately detailed, scenario-specific simulations of urban electromagnetic effects on Air Force systems.

PHASE I: (1) Develop conceptual design for an interface between the high-resolution digital map databases and a sample CAD program. (2) Using this interface design, investigate the construction of CAD models of urban areas appropriate for electromagnetic simulation. (3) Document these results and provide a detailed plan for prototype development in Phase II.

PHASE II: (1) Develop proof of concept prototype CAD software package based on work done under Phase I. (2) Identify issues pertinent to accurate modeling of electromagnetic scattering and diffraction from manmade structures. (3) Refine techniques used to predict scattering and diffraction from manmade structures and implement them.

PHASE III DUAL USE APPLICATION: The commercial potential is excellent. With exponentially increasing reliance on cellular and wireless communications for voice, data, image and video transmission, the technology base developed under this SBIR is expected to be fully exploited by established and emerging companies alike. In addition, the Federal Aviation Administration (FAA) can take advantage of this technology to characterize urban clutter for optimizing the performance of air port surveillance radars.

REFERENCES:

1. K. Sivaprasad, A. Drake and S. Rajan, "Urban Discrete Clutter Sources," Rome Air Development Center Technical Report TR-86-70.

2. R. Akturan, W. Vogel, "Path Diversity for LEO Satellite-PCS in the Urban Environment," IEEE Trans. Antenna. Propagat., Vol 45, no. 7, July 1997, pp11071116.

KEYWORDS: Cad Models, Urban Propagation, Digital Terrain Maps, Urban Terrain Clutter, Electromagnetic Scattering, Urban Electromagnetic Environments

AF99-263 TITLE: Subpixel Detection Concepts For Space-based Infrared Hyperspectral Imaging

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop innovative infrared hyperspectral imaging techniques for space-based day/night surveillance and reconnaissance applications

DESCRIPTION: Infrared targeting systems based solely on spatial and thermal detection phenomenology are fundamentally limited in performance for several important scenarios: extended ranges, wide area search, low contrast conditions, and deep hide and camouflage, concealment, & deception (CC&D) targets. Multispectral discrimination presents an opportunity for significant enhancements in target detectability by exploiting characteristic target spectral (color) features and high background spectral correlation. By extending the spectral information content in this way, the spatial resolution requirements can potentially be relaxed to detect and discriminate target materials which occupy as little as a fraction of a pixel. Results to date under the current program, Brassboard Airborne Multispectral Sensor System Specification (BAMS), have supported this potential of multispectral sensing through extensive spectral measurements and subsequent performance measurements over a range of targets, backgrounds, and environmental conditions. The BAMS program is part of a tri-service research area called the Joint Multispectral Program (JMSP). The performance goals are high probability of detection, low false alarm rates and wide area search capabilities. As part of the BAMS program, multi- and hyperspectral sensor design trades are being refined based on an expanded target/background database. These trades include sensor parameters such as: spectral bands, spectral bandwidths, noise equivalent spectral radiance, band-to-band registration, etc. Currently, the Space-Based Hyperspectral Sensor Technology Initiative was established to provide the warfighter a day/night global surveillance capability to detect and recognize targets and target materials. The initiative capitalizes on the BAMS program by expanding high-altitude airborne reconaissance hyperspectral efforts to mature the technology to the point that demonstration on a space platform is viable. The OBJECTIVE of this SBIR topic is to develop a better understanding of the phenomenology of spectral mixing within a region and to develop sub-pixel detection and classification approaches for an affordable, calibrated, optically-registered multi-band (>100 bands) thermal imaging system using available focal plane arrays. These approaches must focus on satisfying the performance requirements for high probability of detection and low false alarm rate performance for sub-pixel target detection/ classification from a sensor based on a space platform.

PHASE I: Investigate and understand effects of spectral mixing between target materials and background clutter within a region when sensed remotely by a thermal hyperspectral imaging sensor, and determine the potential performance for sub-pixel detection/classification, including fundamental limits of performance using existing thermal spectral data.

PHASE II: Develop sub-pixel detection and classification techniques for a thermal hyperspectral sensor based on performance trades and phenomenology understanding accomplished in phase I. Determine critical sensor performance specifications including selecting thermal wavebands, spatial and spectral resolution, and noise requirements based on developed techniques. Optimize the approach for a selected sensor. This phase should result in the delivery of the sub-pixel detection and classification techniques in a software package.

PHASE III DUAL USE APPLICATION: Many non military target spectral signatures are of interest in the thermal region. Dual use of a sensor employing this technique may be desired for oil and mineral exploration, agricultural assessments, and pollution and environmental monitoring.

REFERENCES:
1. Erdman, Carey D., Robert L. Huguenin, and Lawrence A. Scarff, "Utilizing subpixel identification schemes to address emerging application areas," Proc. SPIE 3119, 196-204 (9/1997)
2. Goetz, Alexander F., Bruce Kindel and Joseph W. Boardman, "Subpixel target detection in HYDICE data from Cuprite, Nevada," Proc. SPIE 2819, 7-14 (11/1996)
3. Harsanyi, Joseph C. and Chein-I Chang, "Hyperspectral image classification and dimensionality reduction: An orthogonal subspace projection approach", IEEE Trans. Geoscience and Remote Sensing, 32(4), 779-785 (1994)
4. Huguenin, Robert L., Karaska, Mark A., and John R. Jensen Subpixel Classification of Bald Cypress and Tupelo Gum Trees in Thematic Mapper Imagery," Photogrammetric Engineering and Remote Sensing, 63(6), 717-726 (Jun 01 1997)
5. Iverson, A. Evan, "Subpixel object detection and fraction estimation in hyperspectral imagery," Proc. SPIE 3071, 61-72 (8/1997)
KEYWORDS: Imaging, Thermal, Subpixel, Infrared, Detection, Hyperspectral, Multispectral, Remote Sensing, Classification, Spectral Mixing

AF99-265 TITLE: Piezoelectric Actuators in High Strain Field

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop innovative piezoelectric actuator concepts which survive in high strain fields for aircraft vibration control.

DESCRIPTION: This SBIR topic supports the Department of Defense's Air/Space Vehicles key technology area as well as the Aging Aircraft and Access to Space Thrusts. Innovative piezoelectric actuator concepts are solicited. These actuators will ultimately be used in the suppression of vibrations in aircraft structures caused by impinging unsteady air loads. The research will develop and characterize piezoelectric actuator concepts that can withstand severe localized strain levels. The research will study reliability and maintainability (R&M) issues involved with the design and integration of the actuator system concepts. The actuators and their support equipment must be light weight, low volume, and must be designed to be integrated into an aircraft system considering environmental, electrical, and mission impacts. The employment of this concept will eliminate or reduce structural vibrations that often lead to fatigue and will improve flight vehicle life cycle costs and mission performance. A working knowledge of vibrations, unsteady aerodynamics, aeroelasticity, fatigue, controls, and aircraft subsystem packaging is required.

PHASE I: Perform design and feasibility investigations (primarily analytical) of the submitted concept considering a current operational aircraft. This research will focus on estimating the benefits attained by implementing a vibration suppression system that utilizes these actuators in terms of reduced fatigue, increased R&M as well as looking at preliminary integration issues.

PHASE II:Perform demonstration and validation test by applying concept developed in Phase I to a dynamically scaled vertical tail structure similar to a full-scale F/A-18 vertical tail.

PHASE III DUAL USE APPLICATION: Vibration suppression systems that utilize robust piezoelectric actuators have applications in a number of military and commercial environments including spacecraft, aircraft, naval vessels, and ground vehicles.

REFERENCES:
1. Lazarus, K.B., Saarmaa, E., and Agnes, G.S., "An Active Smart Material System for Buffet Load Alleviation," Proceedings from SPIE's 2nd Annual International Symposium on Smart Structures and Materials, Volume 2447, 1995, pp. 179-192.
2. Hauch, R.M., Jacobs, J.H., Dima, C., and Ravindra, K., "Reduction of Vertical Tail Buffet Response using Active Control," Journal of Aircraft, Volume 33, Number 3, May-June 1996.
3. Moore, J.W., Spangler, R.L., Lazarus, K.B., and Henderson, D.A., "Buffet Load Allevaition using Distributed Piezoelectric Actuators," Symposium on Adaptive Structures, ASME International Mechanical Engineering Congress and Exposition, Atlanta GA, November 1996.

KEYWORDS: Piezoceramics, Localized Strain, Modal Strain Energy, Vibration Suppression, Buffet Load Alleviation, Piezoelectric Actuators, Active Vibration Control

AF99-266 TITLE: High Temperature Structure Explosive Joining Development Program

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Define, develop and apply explosive joining to high temperature space vehicle structure.

DESCRIPTION: Joining of structural components on future space vehicles is a major contributor to the overall cost, weight and structural performance of the space vehicle. Explosive joining is an advanced method of joining in which controlled energy of a detonating explosive is used to create a metallurgical bond between two or more similar or dissimilar materials. Explosive joining could be used to increase the affordability of aircraft structures by eliminating costly mechanical fastening or splices in structural design and increasing the structural durability in a severe high temperature environment. Explosive joining also could replace areas of a space vehicle with bimetallic materials which are more affordable and durable than what is used in common design and manufacturing practices today. In addition, explosive joining could also be used in space vehicle structural repair. The creative use and application of explosive joining will increase the affordability and structural performance of the vehicle, while satisfying the severe high temperature structural requirements of the space vehicle.

PHASE I: Phase I would involve the analysis of a space vehicle and selection of a potential candidate structure that could be fabricated from the application of explosive joining to the specific part or built-up structure. The candidate would be selected based on known areas that need improvement, concentrating on areas of the vehicle subject to severe thermal loading. Examples could include heat exchangers, elevated temperature metallic tankage, and unprotected metallic control surfaces. Initial explosive joining trials would be conducted to address joint design properties for the necessary high temperature aerospace alloys used in the proposed space vehicle structure.

PHASE II: Phase II would involve the redesign of the space vehicle part or built-up structure to facilitate explosive joining to decrease structural cost and weight. The candidate part redesign task would include significant coupon and subelement testing to develop the design data and structural testing to validate the proposed designed part or built-up structure. This building block approach would create the necessary design data base and joining parameters to validate the use of explosive joining in high temperature space vehicle parts and built-up structure.

PHASE III DUAL USE APPLICATIONS: This advanced method of joining offers design alternatives for future space vehicle structures as well as opportunities for weight and cost savings for future military aircraft such as the Joint Strike Fighter and for current military aircraft such as the F-15, F/A-18 and F-22. Explosive joining could impact the fabrication of commercial aircraft through cost and weight reduction, also. The use of explosive joining could be further expanded to include ship building, the chemical processing industry, the nuclear and gas pipeline industries and automobile and bus manufacturing.

REFERENCES: WL-TR-97-3033,"Explosive Joining Application Study," January 1997., WL-TR-97-3034, "Advanced Structural Joining," January,1997.

KEYWORDS: Cladding, Explosive Welding, Explosive Joining, Bimetallic Bonding, Explosive Cladding

AF99-267 TITLE: Extreme Environments Support/Space Applications

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop structural concepts (TPS, tanks, structures) and methodologies to assess hypersonic air vehicle structures manufactured with advanced materials

DESCRIPTION: There is an increased focus on the technologies necessary to develop airframe structure using advanced materials, for high speed vehicles, operating under severe thermal and acoustic loads. These loads, caused by high speed (>M 5) in the atmosphere and atmospheric reentry, are driving the design of these vehicles. Durable, lightweight thermal protection systems, hot structures, actively cooled structures and tanks that are affordable are necessary to meet expected weight goals. Many materials technologies have matured significantly since the National Aerospace Plane Program, these material advances, combined with advances in computational methods, need to be researched to achieve current system goals. Research efforts could involve the evaluation of using advanced materials, such as ceramic matrix composites and graphitic foam, or advanced processes such as E-Beam curing to develop and analyze high-speed vehicle structures. In addition, research in the methodologies necessary to develop these advanced structures could also be accomplished.

PHASE I: Develop analytical methodologies and concepts

PHASE II: Methodologies and concepts developed in Phase I will be validated by experimentation.

PHASE III DUAL USE APPLICATIONS: The development of structures using advanced materials can be transferred into the commercial market in both the aircraft and automotive industries. The development of these new structures will result in stronger, lighter more efficient commercial aircraft and automobiles.

REFERENCES:
1. "Dynamic Fatigue of Carbon-Carbon Thermal Protection Systems" H. C. Croop, M. P. Camden, K. R. Wentz, 37th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference AIAA-96-1618, Salt Lake City, Utah April 15 - April 17, 1996.
2. "Thermo-Mechanical Evaluation of Carbon-Carbon Primary Structure for SSTO Vehicles" H. C. Croop, H.B. Lowndes III, S. E. Haun and C. A. Barthel Space Technology & Applications International Forum, Albuquerque, New Mexico, 25-29 January 1998. 3. "High Cycle Fatigue Testing of BlackglasTM Composite Coupons using a Half Sine Clamp" M. P. Camden, D. B. Paul, L. W. Simmons, H. F. Wolfe, L. W. Byrd, R. R. Batzer 68th Shock and Vibration Symposium Hunt Valley, Maryland November 3 - 7, 1997

KEYWORDS: Hot Structures, Cryogenic Tanks, Military Space Plane, Hypervelocity Vehicles, Space Operation Vehicles, Ceramic Matrix Composites, Activity Cooled Structures, Thermal Protection Systems

AF99-268 TITLE: Deformation Measurement for Conformal Loadbearing Antenna Structure Arrays

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop a structural deformation measurement system for large high frequency conformal loadbearing antenna structure arrays.

DESCRIPTION: The Air Force is pursuing the development of conformal loadbearing antenna structure (CLAS). CLAS features radio frequency (RF) antennas embedded in the loadbearing skin of aircraft structure. This concept provides improved antenna performance from increased aperture size as well as structural integrity, weight, cost, and signature payoffs. This solicitation is focused on a need to develop a system capable of measuring the deformation or displacements of large high frequency CLAS arrays induced by flight. The displacements will be used for real time array phase compensation. The goal of this solicitation is to develop an environmentally robust displacement measurement system capable of operation in electromagnetic fields characteristic of RF transmission and reception. This measurement system must provide the accuracy required for a CLAS array phase compensation system. In addition, the system must be non-obtrusive, structurally embeddable, and capable of surviving manufacture processing and the flight environment.

PHASE I: Demonstrate the feasibility of an approach to accurately measure displacements of a large high frequency CLAS array.

PHASE II:Demonstrate the performance and structural integrity of the displacement measurement system in a representative CLAS component.

PHASE III DUAL USE APPLICATION: This technology will be applicable to all military air vehicles and space systems using large high frequency RF apertures. Commercially, this technology will broaden the application of CLAS technology to airline and civil aircraft to provide efficient high frequency RF communications for passengers' personal computing, data communications, video, cellular phones, high definition television, and more. This technology will also benefit large spaced based antenna arrays for commercial satellite systems.

REFERENCES: "Structurally Integrated, Conformal Smart-Skin Antennas for Military Aircraft - Issues and Payoffs," Conference Proceedings, Society of Photo-Optical Instrumentation Engineers, Orlando, Florida, 13-18 February 1994.

KEYWORDS: Arrays, Antenna, Deflection, Structures, Deformation, Measurement

AF99-269 TITLE: Unstable Random Vibration Response of Composite Panels

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop analytical expressions for the unstable random vibration response of composite panels with simultaneous thermal and acoustic loads.

DESCRIPTION: The assessment of the fatigue life and the effects on aerodynamic shapes for the thermal acoustic loads on supersonic and hypersonic vehicle structurrs is needed. Previous efforts made various attempts at solving the plate stability problems. New approaches to the instability problem are sought. The solution procedure should account for the interdependency between the thermal effects and the acoustic structural response. Consideration should be given to the critical temperature change that produces plate buckling, temperature gradients along the edge and improvements in numerical integration methods and iterative procedures. The analytical techniques should and include the use of high temperature composite materials such as ceramic matrix composites.

PHASE I: Develop new analytical methods for unstable composite plates.

PHASE II: Demonstrate the new analytical method by example and validate using a database.

PHASE III DUAL-USE APPLICATIONS: Military space plane and the high speed civil transport.

REFERENCES:

1. Seide, P. and Adami, C., "Dynamic stability of beams in a combined thermal-acoustic environment," Technical Report AFWAL-TR-83-3027, WPAFB, OH, October 1983, AD A 142 424.

2. Ng, C.F., "Nonlinear and snap through responses of covered panels to intense acoustic excitation," Journal of aircraft, Vol 26, 1989, pp. 281-288.

3. Chen, R., and Mei, C., "Thermo-mechanical buckling and vibrations of thermally buckled of composite plates of arbitrary shape using first-order transverse shear elements," Symposium on Buckling and postbuckling of composite structures, ASME Winter Annual Meeting, pp 39-53.

4. Murphy, K.D., Theoretical and Experimental Studies in Nonlinear Dynamics and Stability of Elastic Structures. Ph.D. dissertation, Duke University, Durham, NC, 1994 (Available through University Micro Films, Order Number AAD95-00492, 1-800-521-0600.).

5. Lee, J., "Random Vibration of Thermally Buckled Plates: II Nonzero Temperature Gradient Across the Plate Thickness," Appl Mech Rev Vol 50, No. 11, Part 2, November 1997.

KEYWORDS: Snap Through, Composite Plates, Thermal Buckling, Random Vibrations, Acoustic Excitation, Probability Density Functions

AF99-271 TITLE: Modern Methods for Flying Qualities and Stability and Control Analysis

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop interactive tool for UCAV stability and control/flying qualities of hypersonic control effectiveness.

DESCRIPTION: Currently available software for assessing the flying qualities or stability and control characteristics of UCAV is typically run in a "batch" mode on a PC or workstation.. Within this environment, there is no capability for interactive analysis with simultaneous online documentation of the underlying theory used to generate the data. It is also cumbersome to generate the required data for flight simulation using current software. New configurations could be studied in a much more efficient manner if this capability was available. This would reduce flight control system development cost. For hypersonic vehicles, there is a need to develop alternate control effectors based on flow control.

PHASE I: Expectations for this phase would be a working version of a tool that performed calculations for one vehicle component with associated on-line documentation. For a hypersonic control effector, analytic predictions of effectiveness and costs should be available.

PHASE II: Expectations for this phase would be an interactive tool applicable to a complete vehicle including a flight control system. For a hypersonic control effector, wind tunnel tests and possibly fabrication of a full-scale device would be expected.

PHASE III DUAL USE APPLICATIONS: The flying qualities tool could be used for UAVs of any type, both military and civilian, while the stability and control tool could be used for UAVs or manned vehicles. The high cost of proposed commercial uses of space could be reduced with innovative hypersonic configurations or control effectors.

REFERENCES: Control Dynamics Branch home page, http://www.wl.wpafb.af.mil/flight/fed/fige

KEYWORDS: Flying Qualities, Hypersonic Control, Stability and Control, Uninhabited Air Vehicles, Unmanned Combat Air Vehicles

AF99-272 TITLE: Aeromechanics for Future Aircraft Technology Enhancement

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop aeromechanics for affordable 21st century aircraft with significant improved speed, maneuverability, range and survivability.
DESCRIPTION: The United States Air Force has a vital interest in the development of manned and unmanned aircraft with significant advancement in flight performance and mission effectiveness. These advanced vehicles will rely on innovation in aeromechanics technology to achieve new levels of speed, maneuverability, range, payload capability, life cycle cost and rapid design development. Advancements are needed in the following areas: a) accurate engineering design methods for determining aerodynamic characteristics and flight performance of unconventional aircraft, b) accurate, efficient computational fluid dynamics methods to describe both steady and unsteady airflow about air vehicles, c) flow control devices which can be used to reduce drag or improve inlet or nozzle performance, d) efficient integration of inlets and nozzles and e) innovative aircraft configurations which produce advanced performance capabilities for a wide range of air vehicles operating in the subsonic through hypersonic flow regimes.

PHASE I: Define the proposed concept, outline the basic principles, and establish the method of solution. Present an example of the advanced performance which will result from the technology. Determine the risk and extent of improvement over existing methods.

PHASE II:Build a prototype application of the equipment or software. Demonstrate the advanced technology under actual engineering conditions.

PHASE III DUAL USE APPLICATIONS: Improved performance and safety of commercial and private aircraft will be realized with the application of this technology. New areas of commercial growth will result from aircraft design tools which allow fast and accurate development of air vehicles to respond to aircraft needs around the world. Examples are devices which allow aircraft to operate from remote fields, carry large payloads at low cost, and are economical to produce and operate. New aerodynamic analysis tools will improve education methods and allow industry to produce with lower initial investment.

REFERENCES:
1. "Requirements for Effective Use of CFD in Aerospace Design," Pradeep Raj; NASA Conference Proceedings #3291, pp 15-28, NASA Lewis Research Center, Cleveland, Ohio, May 1995. (95N28725)
2. "Propulsion Integration Issues for 21st Century Fighter Aircraft." Marvin Gridley and Steven Walker, Paper #42 in Proceedings of AGARD Propulsion Energetics Panel, Seattle, Washington, Sep 1995. (96N36606)
3. "Proceedings and Design Data for the Formulations of Aircraft Configurations," T.R. Sieron, et al, WL-TR-93-3068, Wright Laboratory, Air Force Materiel Command, Wright-Patterson AFB, OH, Aug 1993. (ADA 270 150)

KEYWORDS: Inlets, Nozzles, Hypersonics, Integration, Aerodynamics, Aeromechanics, Active Flow Control, Aircraft Configurations, Computational Fluid Dynamics (CFD)

AF99-273 TITLE: Hypersonic Flow Control

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop methods and devices to modify aerospace vehicle airflows to control drag, heating, and maneuverability.

DESCRIPTION: Sustained hypersonic flight offers potential revolutionary improvements in warfighting and space launch. Limiting factors in vehicle performance include aerodynamic heating, pressure and viscous drag, and maneuverability. Flow control methods and hardware developed for subsonic and supersonic flows are generally ill-adapted to the hypersonic flight environment. Active and passive flow control methods which are survivable, take advantage of the unique characteristics of hypersonic airflow, and which may be integrated into hypersonic vehicles, are sought.

PHASE I: Define the physical mechanisms by which flow control is effected and develop relationships (theoretical or empirical) between the input and desired output. Conduct or at least define tests demonstrating the feasibility of the method. Present concepts for vehicle integration and maintainability, and present an example of the effect of the flow control method on vehicle performance.

PHASE II:Construct a bench-scale flow control system using methods defined in Phase I. Demonstrate the concept in laboratory tests. Analyze the costs and benefits of the technique as applied to an aerospace vehicle.

PHASE III DUAL USE APPLICATIONS: Flow control concepts developed under Phases I and II may potentially be applied to civilian space launch and high speed air vehicles. Flow control hardware which operates in hypersonic flight may have civilian application in high temperature environments such as furnaces, engines, materials processing, and manufacturing.

REFERENCES:

1. Future Aerospace Technology in the Service of the Alliance, Volume 3, Sustained Hypersonic Flight, AGARD-CP-600 Vol. 3, December 1997
2. Bityurin, V. A., Zeigarnik, V. A., and Kuranov, A. L., "On a Perspective of MHD Technology in Aerospace Applications," AIAA paper 96-2355, 27th AIAA Plasmadynamics and Lasers Conference, June 1996.

KEYWORDS: Drag, Plasma, Acoustics, Hypersonics, Aerodynamics, Active Flow Control, Aerodynamics Heating, Boundary Layer Transition, Multidisciplinary Analysis, Multidisciplinary Optimization

AF99-274 TITLE: High Temperature, Structural Load Bearing Heat Exchanger Technologies

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop technologies to transfer aerospace vehicle heat loads through high temperature, and structural load bearing heat exchangers.

DESCRIPTION: Heat exchanger maximum operating temperature and packaging constraints (volume/weight) onboard aerospace vehicles have always been a challenge. Current heat exchanger requirements limit the use of high temperature materials and efficient manifold designs. With increased emphasis on aerospace vehicle platform size and range, this problem has become more critical. The emphasis in design is now becoming the development of heat exchangers with decreased weight and volume which operate at much higher temperatures. This will be especially critical for the next generation aerospace vehicles that utilize heat exchangers to transfer heat from exhaust washed and leading edge structures. One solution to this problem is to develop a heat exchanger which functions as both the manifold, or container for the heat exchanger core, and as an integral structural member. In addition to weight and volume reductions, this approach should improve system-level heat management by improving thermal contact with structural elements which are either a heat source (e.g., leading edge) or a heat sink (e.g., outer skin surface). These benefits have the potential to improve aerospace stealth characteristics, dynamic stiffness, and provide greater range or payload capabilities. The heat exchangers will be operating with fluid/surface temperatures in the range of 300-1700 Deg F. The effort to be performed will develop innovative concepts for high temperature, structural load bearing heat exchangers providing controlled cooling in aerospace vehicles. This technology will be critical for aerospace vehicles.

PHASE I: During Phase I, analysis and conceptual design work will be performed to evaluate the feasibility of developing a high temperature and structural load bearing heat exchanger. This will include consideration of potential acoustic and vibration loads. Analysis of heat exchangers fabricated (both core and manifold shell) from various high temperature materials shall be included. The analysis and conceptual design will also address the compatibility of developed concepts with the aerospace vehicle and its subsystems. The design will show sufficient technology maturity for orderly development into aerospace systems with compatible environmental factors. The Phase I work will produce a competent technical report and plans for experimental development in a proposed Phase II effort.

PHASE II:This phase continues the necessary analytical work and provides experimental verification of predicted heat exchanger operating capabilities for high temperature and structural loading materials. Laboratory simulation of typical aerospace vehicle operating conditions will evaluate heat exchanger performance at various fluid inlet flow rates, temperatures, and heat loads. Benefits to be gained from the use of the high temperature, structural load bearing heat exchangers will be quantitatively established for various aerospace applications to prepare for possible commercial development of the heat exchanger. A comprehensive technical report will document all of the work conducted, a final optimized design will be completed, and a demonstration heat exchanger will be fabricated.

PHASE III DUAL USE APPLICATIONS: Dual use commercialization will be considered in all phases of this effort. Potential commercial applications include in-flight cooling on the High Speed Civil Transport (HSCT), industrial process heat exchangers, and integrated cooling for commercial satellite launch systems.

REFERENCES:
1. "Long-Term Materials Test Program" (Quarterly Report, January-March 1983), General Electric Co., Schenectady, NY., Report No.: DOE/ET/15457-1522, Journal Announcement: GRAI8418; NSA0900, Mar 84, NTIS Accession Number: DE84008899.
2. "Development of a Ceramic Tube Heat Exchanger with Relaxing Joint" (Final Report, January 1977-June 1980), Ward; Solomon; Gulden; Smeltzer, Solar Turbines International, San Diego, CA., Journal Announcement: GRAI8310; NSA0500, Jun 80, NTIS Accession Number:
FE-2556-30.
3. "Experimental Study of Flow Characteristics of Offset Fin and In-line Fin Arrays (Effects of Fin Thickness and Fin Pitches on Flow Instability)," Society of Mechanical Engineers (Journal Article | Part B v 59 n 560 Apr 1993 p 1222-1227), Hagiwara;

Yoshimichi; Xi; Guannan; Futagami; Shunzou; Suzuki; Kenjiro, Journal Announcement: 9310W2, E. I. Number: EIP93081051221.
4. "Heat-Exchanger Body-to-Closure Bolted Flange Connection," Soviet Energy Technology (Journal Article | n 5 1989 p 28-30), Efremov; Kerimbaev; Chimchikov, Journal Announcement: 9012, E. I. Number: EI9012137696.
5. "Load-Bearing Capacity of Heat Exchange Pipes of Polymer," Chemical and Petroleum Engineering (Journal Article: v 20 n 7-8 Jul |Aug 1984 p 330-331), Kuz'menko, Journal Announcement: 8509, E. I. Number: EI85051687.
KEYWORDS: Load Bearing Structure, Leading Edge Structures, Aircraft/Subsystem Cooling, Exhaust Nozzle Heat Transfer, Launch Vehicle Heat Transfer, High Thermal Conductivity Materials

AF99-275 TITLE: Instantaneous Temperature Measurement System

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Development of robust temperature measurement systems with micro-second response times.

DESCRIPTION: There is currently no commercially available temperature sensor that can react fast enough to quantify nearly instantaneous (1 microsecond) temperature changes. This limitation prevents the accurate determination of temperature increases behind a shockwave due to an explosion in a fluid-filled medium. This effort involves the development of a system that can quantify these rapid temperature changes behind such an explosive shock wave. The system will be used by the Air Force Research Laboratory to describe fully the temperature fluctuations behind a 3 dimensional shock wave in a large (5 ft diameter, approximately 5 ft high) open-top, fluid-filled container with transparent viewports. The shock wave will be generated by a High Explosive Incendiary (HEI) shell detonation near the center of the container. Due to the explosive reactants, detonation of the HEI shell renders the fluid opaque. Because of the envisioned service environment, the system must be very robust. For an in-tank system, probes must be capable of surviving an instantaneous shock wave pressure of approximately 30 ksi, must not be effected by the fluid environment and must be able to use several gauges simultaneously to obtain an accurate description of the 3-D temperature change. For an out-of-tank system, the equipment must be able to work through the thick glass viewports, must be water resistant and must not be affected by the opacity of the fluid behind the shock wave. For all systems, the temperature sensors must have a response time of approximately 1 microsecond and must be resistant to severe electro-magnetic noise. The overall system must be able to record up to 0.1 seconds of data and the temperature reading must be as accurate as possible up to 2000oC. The preferred system would also be able to adapt to any given test configuration (i.e. closed container, aircraft wingbox, 1-D shock tube, no transparent viewports, etc.) The system will be used to validate hydrocodes currently used to simulate hydraulic ram phenomena.

PHASE I: A prototype system will be designed to capture rapid temperature fluctuations behind a shock wave. The design will be supported numerically and through proof-of-concept tests.

PHASE II:A prototype temperature measurement system will be developed, tested and delivered. The system will be able to characterize fully the rapid temperature fluctuations behind a shock wave in a fluid-filled environment.

PHASE III DUAL USE APPLICATIONS: A very robust instantaneous-temperature-measurement system would be a useful tool to any industry involved in combustion processes. This tool could potentially aid automakers in designing fuel injectors or combustion chambers that would optimize fuel distribution and burn. It could also be used by jet engine manufacturers to help visualize flow throughout an engine or to optimize the combustion process.

REFERENCES:
1. Lawton, B., and Klingenberg, G., Transient Temperature in Engineering and Science. Oxford: Oxford University Press, 1996.
2. Kidd, S. R, Barton, J. S., and Jones, J. D., "Demonstration of an optical fibre probe for high bandwidth thermal measurements in turbomachinery," Proceedings of the 10th International Conference on Optical Fibre Sensors, 10th, Society of Photo-Optical Instrumentation

KEYWORDS: Explosion, Shock Wave, EMI Resistant, Instrumentation, Fluid-filled Container, Temperature Measurement

AF99-276 TITLE: Enhanced Conduction, Radiation, and Ionic Heat Transfer for Aerospace Vehicles

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop high conductivity solids, enhanced radiation, and/or ionic transport for heat transfer in aerospace vehicles.

DESCRIPTION: Thermal management onboard flight vehicles and space satellites is always a challenge. Standard approaches require substantial mass and power, both of which affect total vehicle size, payload and range. Continued growth in the density of electronics and other items mounted in the vehicles, combined with new operational needs such as reusable space launch systems or hybrid air/space vehicles, and long duration flight of uninhabited air vehicles (UAV), requires the development of new and innovative methods for heat transfer. Total heat loads for long endurance UAVs are expected to be in the 15 to 50 kW range. Internal heat loads for other aircraft, reusable launch systems and satellites will vary widely depending on the type of system and the configuration. Methods to transfer heat from dense sources to the structure or skin of the vehicle, or to thermally isolate equipment from hot structure, need to be simple, dependable, lightweight, and efficient. Reduction or elimination of moving parts is an important goal. Thermal conduction through solids, use of dissimilar metals, and use of ion transport are among the candidate approaches to consider. Coatings and surface treatments will, of course, also have an effect. Avoiding the use of convective fluids can simplify the thermal management equipment and prevent problems in the weightless environment of space. Proposed technical approaches for this topic must show promise of significantly improved performance compared to thermal conduction in ordinary solids but without the use of convective fluids. This topic represents critical subsystem technology for air vehicles and space vehicles.

PHASE I: Analysis, conceptual design work, and optional simple experiments will be performed to evaluate the feasibility of developing the selected heat transfer method(s). This will include analysis of the relative merit of the new, innovative approach in comparison to conventional heat transfer for conditions of interest in piloted military aircraft and UAV's (0 to 60,000 feet altitude) and other aerospace vehicles. The analysis and conceptual design will also address the compatibility of developed technologies with the vehicle and its subsystems. The design will show sufficient technology maturity, practicality, and payoff benefit for orderly development in the next phase of effort. The Phase I work will produce a competent technical report and plans for experimental development in a proposed Phase II effort.

PHASE II:This phase continues the necessary analytical work and provides experimental verification of predicted heat transfer capacities for the selected approach. Laboratory simulation of typical operating conditions will evaluate performance at various altitudes and heat loads. Any environmental restrictions will be assessed. Benefits to be gained from the use of the new approach will be quantitatively established for different potential applications to prepare for possible commercial development of the system. A comprehensive technical report will document all of the work conducted, a final optimized design will be completed, and a demonstration device will be fabricated and tested.

PHASE III DUAL USE APPLICATIONS: Dual-use commercialization will be considered in all phases of this effort. Potential commercial applications include in-flight cooling on the High Speed Civil Transport (HSCT), general aviation aircraft, large facility cooling (e.g., air conditioning), and commercially developed reusable space launch systems.

REFERENCES:
1. "Preliminary Design and Analysis of an Advanced Heat-Rejection System for an Extreme Altitude Advanced Variable Cycle Diesel Engine Installed in a High-Altitude Advanced Research Platform," Johnston, R. P. DieselDyne Corp., Morrow, OH., Report No.: NAS 1.26:186021; H-1775; NASA-CR-186021, Jul 92, NTIS Accession Number: N92-29427/1/XAB.
2. "Development of a Self Contained Heat Rejection Module, Phase 2 and 3" (Final Report), Fleming, M. L., Vought Corp., Dallas, Tex. Systems Div. Report No.: NASA-CR-151109; T211-RP-032, 17 Aug 76, NTIS Accession Number: N77-12068/1.
3. "Integrated Engine Inlet Thermal Anti-Icing and Environmental Control System (TAI/ECS)," Shaw, A. D., Boeing Commercial Airplane Co., SAE Paper 760517 (available from AIAA Tech. Library), May 76.
4. "Nonmetallic Crystals With High Thermal Conductivity," Slack, G. A., General Electric Research & Development Center, J. of the Physics and Chemistry of Solids, Vol. 34, No. 2, pp. 321-335, Feb. 73.
5. "Shear Flow Effects on Ion Thermal Transport in Tokamaks," Tajima, T., et. al, Univ. of Texas at Austin, DOE Report No. DOE-ET-53088-697, Mar. 95, NTIS Accession No. DE95009115/XAB.

KEYWORDS: Ion Transport, Heat Rejection, Dissimilar Metal Devices, Aircraft Subsystem Cooling, Launch Vehicle Heat Transfer, High Thermal Conductivity Solids

AF99-277 TITLE: Enhanced Dry Chemical Fire-Extinguishing Agents

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Development of an enhanced dry chemical fire-extinguishing agent.

DESCRIPTION: Simple dry chemical fire suppressants such as sodium bicarbonate and ammonium phosphate are highly effective in extinguishing fires and in suppressing explosions. These materials have little environmental or toxicological impacts, and provide rapid-fire knockdown. Their disadvantages include (a) no inhibiting atmosphere after discharge, (b) no direct cooling of surfaces or fuel, (c) possible secondary damage, (d) cleanup, and (e) visual obscuration. Modification of dry chemical extinguishants offer an opportunity for major enhancement of suppression and inertion performance by providing longer-term suppression capability and/or reducing the amount of agent needed. Dramatic improvements in dry agents may allow their use as replacements for ozone depleting halons in fire suppression applications. Enhancement of dry chemical suppression and inertion can be achieved by particle size reduction; however, most methods for generating small particulates (e.g., pyrotechnically generated aerosols) have major drawbacks, and performance enhancement is insufficient to allow substitution for halons in most applications. Performance enhancement is particularly promising through modification of surface morphology or bulk particulate chemistry changes (e.g., doping).

PHASE I: Identify and assess mechanisms for enhancing dry chemical suppression. Prepare modified agents and conduct laboratory studies to identify the most promising technologies.

PHASE II: Develop processes for production of enhanced dry chemical suppressants and perform a proof of concept demonstration of the enhanced dry chemical suppressants.

PHASE III DUAL USE APPLICATIONS: Develop and demonstrate large scale processes for production of the enhanced dry agents. All commercial facilities and industries where rapid fire detection and suppression would increase the survivability of people and protection of resources. All commercial facilities would include but not limited to the automotive industry, commercial cruise lines and/or other sea transportation.

REFERENCES: Ewing, C. T., Faith, F. R., Hughes, J. T., and Carhart, H. W., "Flame Extinguishment Properties of Dry Chemicals: Extinction Concentrations For Small Diffusion Pan Fires," Fire Technology, Vol. 25, pp. 134-149, May 1989.

KEYWORDS: Halon, Dry Chemicals, Inertion Agents, Fire Suppressants

AF99-278 TITLE: Advanced Stochastic Techniques for Finite Element Vulnerability, Fatigue, Corrosion Simulation

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop efficient methods for stochastic modeling involving finite element damage simulations common to vulnerability, fatigue, and corrosion.

DESCRIPTION: The ever increasing reliance of Department of Defense planners and developers on computer simulation and modeling places a premium on increasing the computational efficiency of these methods. Monte Carlo methods, for example, typically consume extensive computational resources. This research deals with the rapid generation and execution and statistical post processing of multiple finite element models of structures for purposes of monte carlo simulation of survivability/vulnerability, fatigue and corrosion damage.

A number of technology areas require that multiple (a number sufficient for statistical confidence) finite element models of damaged structures be analyzed in the context of a Monte Carlo Simulation. Important cases of this situation which require identical types of analysis include vulnerability analysis of weapon effects on aircraft structures, effects of multi-site fatique damage, residual strength of structures subjected to intergranular corrosion, and large strain deformation of materials and structures incurring internal damage. In these problems a basic structure is repeatedly analyzed subjected to fixed loads in the presence of statistical realizations of a variable load distribution, number of discrete loads and corresponding load application points, a size and number density distribution of ideal geometrical slits, penny shaped cracks or cutouts simulating damage due to a variety of causes such as fragment perforations, fatigue crack populations, or populations of intergranular cracks. In all these cases a parameter (order parameter) associated with the load or damage distributions can reach a critical value at which the structure incurs a complete loss of its strength or stiffness. The order parameter may be product life and the growth of the damage modeled by some stochastic process model such as DLA, Diffusion Limited Aggregation. A finite element model is unable to analyze this state due to the infinitesimal size of the elements required. In the vicinity of this critical value, it is known that the average retained strength or stiffness fits a power law function of the difference of the order parameter from its critical value. Subsequently, performing a Monte Carlo Analysis of the structure in the vicinity of the critical parameter (critical phase transition) will yield results, the average of which must be fitted to a power law curve to infer the critical parameter value as well as the exponent of this variation. The asymptotic behavior near the critical point is known to be independent of the geometry of the damage for example. The Government can realize substantial savings if a single efficient common analysis approach is made available to all these ostensibly separate areas which require performance of the same type of finite element analysis of geometrically modelled damage. It is also of interest to deduce the variance of the statistical distribution for use by designers of such structures and the associated power laws describing them.

PHASE I: Analyze current methods and desired future capability for stochastic modeling in the disciplines subject of this research, especially where computer resources required or turn around time are excessive. Outline techniques with potential for increasing the efficiency and reducing turn around time for these kinds of analysis.

It is desired that the investigators demonstrate the promise of an eventual capability by analyzing the sample problem of the residual strength and stiffness of a circular plate of uniform thickness supported on a clamped outer circular boundary and loaded by a uniform normal load while containing a random distribution of holes normal and through its thickness. The average variation and variance of the stiffness is desired and the value of the critical void fraction and power law exponents as the critical void fraction is approached. The material cases shall be assumed to be brittle and linear elastic combined with hardening plasticity. The problem may be analyzed by current techniques with the option of incorporating some solution speed up techniques and documenting the order of magnitude advantages which will be realized in Phase II.

PHASE II: A prototype model design incorporating the principal types of stochastic analyses involving Monte Carlo Techniques in which finite element models from the disciplines of interest are used will be developed.

PHASE III DUAL USE APPLICATIONS: Commercial, manufacturing and government concerns make extensive use of stochastic modeling techniques. Fatigue and Corrosion Life Estimation and Combat Structural Vulnerability Assessment applications abound. Incidence of product liability litigation fuels demand for commercial sector stochastic modeling. More efficient stochastic modeling methods will reduce costs and increase market potential.

REFERENCES:
1) Nelson, Barry L., "Stochastic Modeling: Analysis and Simulation", McGraw-Hill, Inc. (1995) , ISBN 0-07-046213-5.
2) Krajcinovic, Dusan, "Damage Mechanics", Elsevier Science B. V., (1996), ISBN 0-444-82349-2.
3) Stauffer, Dietrich, and Ammon Aharony, "Introduction to Percolation Theory", Taylor and Francis Ltd., (1992), ISBN 0-7484-0027-3.

KEYWORDS: Damage Mechanics, Percolation Theory, Monte Carlo Techniques, Universal Scaling Laws, Finite Element Analysis, Critical Phase Transition Points

AF99-279 TITLE: Active Shock-Boundary Layer Control for Drag Reduction

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Improved Aircraft Cruise and Maneuver L/D Performance.

DESCRIPTION: The systematic reduction of aircraft wing drag can lead to L/D improvements exceeding 25% in both the cruise and maneuver flight regimes. Prior Air Force efforts on aircraft wing drag reduction have focused on laminar flow control, turbulent skin friction reduction and induced drag minimization. All of this research has been successful, in varying degrees. However, none of the profile drag reduction concepts developed have yet been transitioned to aircraft fleet applications, and only the winglet concept of induced drag reduction now appears in the active transport aircraft fleet. A fruitful area for future wing drag research, with a high transition potential, is shock-boundary layer interaction control. Active flow control devices: micro-electromechanical systems (MEMS), micro vortex generators and shaped memory alloy (SMA) devices to mention several, have evolved to the point that it is now practical to provide appropriate active aerodynamic control on a wing surface that will reduce the shock- boundary layer interaction drag increment under both cruise and maneuver flight conditions. Furthermore, analytical tools are available that can be used to accurately position the active shock-boundary layer control devices to maximize wing/airfoil L/D performance improvement. The thrust of this project is the development, demonstration and aerodynamic performance validation of an active shock-boundary layer control system(s) that effectively reduces wing drag during cruise (first priority) and maneuver (second priority).

PHASE I: Analytically develop an active shock-boundary layer control system(s) designed to improve aircraft wing L/D performance. Flow control effector concepts utilized in the system must have a developed experimental data base.

PHASE II: Active shock-boundary layer control system(s) experimental performance validation, on a representative aircraft airfoil/wing wind tunnel model.

PHASE III DUAL USE APPLICATIONS:
Military applications of the Phase II developed shock-boundary layer L/D improvement system include transport aircraft wings, cruise drag reduction and combat aircraft wing applications, both cruise drag reduction and maneuver L/D improvement. Commercial application candidates for this technology include high speed general aviation aircraft and commercial transport aircraft.

REFERENCES:
1. McManus, K.R. and Magill, J.C., "Airfoil Performance Enhancement Using Pulsed Jet Separation Control," AIAA 97-1971, 4th AIAA Shear Flow Conference, June 29-July 2, 1997, Snowmass Village, CO.
2. Rathnasingham, R. and Breuer, K.S., "Characteristics of Resonant Actuators for Flow Control," AIAA 96-0311, Jan. 1996.
3. Saddoughi, S.G., "Experimental Investigations of On-Demand Vortex Generators," Center for Turbulence Research, Annual Research Briefs, 1994, pp. 197-203.

KEYWORDS: Aerodynamics, Drag Reduction, Neural Network, MEMS Flow Effector, Active Flow Control, Shock-Boundary Layer Interaction

AF99-280 TITLE: Innovative Techniques for Prediction and Control of Dynamic Loads

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Investigate new and novel concepts for predicting and controlling dynamic loads on aircraft.

DESCRIPTION: Many aircraft in the current fleet have had or are experiencing failures due to high dynamic loads. Acoustic loads and buffet can significantly reduce the life of the structure and lead to frequent inspection and costly repair or replacement of various structure on the aircraft. New unique and novel concepts or approaches are needed to ensure that current technology is fully exploited for the wide variety of acoustic and dynamic environments. Prediction techniques are needed that are computationally efficient yet capture the important flow physics (e.g., viscous effects, separation, etc.). Current active control research can be exploited to control these environments and hence reduce the related fatigue causing structural damage. Numerous actuators have been tested to date with very promising results. These include both flow control for acoustic suppression and piezoelectric actuators for structural vibration control. Flow control actuators include fluidic jet or nozzle, flaps, thermal energy, and other devices, which can inject time dependent energy into the flow and reduce the acoustic levels.

PHASE I: Determine the technical merit and feasibility of the approach.

PHASE II: Demonstrate the selected analytical method or control technique.

PHASE III DUAL USE APPLICATION: Methodology could be incorporated into commercial software for use by the automotive industry, commercial aircraft companies, or other industries. Control devices could be used in any industry with dynamic load or acoustic noise problems.

REFERENCES:
1) Shaw, L. and Huttsell, L., "Prediction and Control of Dynamic Loads to Improve Structural Integrity", Paper presented at the USAF Structural Integrity Program Conference, November 1995.
2) Paul, D. and Hopkins, M., "Structures Technology for Future Aerospace Systems," AIAA-98-1869, April 1998.
3) Mabey, D. G., "Some Aspects of Aircraft Dynamic Loads Due to Flow Separation," Royal Aircraft Establishment Tech Memo Aero 2110, July 1987.
4) Betry, M. R., and Rohrer, L.A., "Literature Survey of Aircraft Cavity Flow," AFWAL-TR-83-160-FIMM, May 1982.

KEYWORDS: Loads, Control, Dynamics, Acoustics, Computational, Aeroelasticity

AF99-284 TITLE: Rapid Charging for Electric Ground Support Equipment

TECHNOLOGY AREA: Surface/Under Surface Vehicles/Ground Vehicles

OBJECTIVE: Develop a standardized rapid charging system to enable electric ground support equipment to meet mission requirements with minimal downtime for battery charging.

DESCRIPTION: Ground support vehicles range in size from forklifts to aircraft tow tractors and are used to support flight-line operations. They are conventionally powered by internal combustion diesel or gasoline engines. Hybrid electric drive and electric drive systems are currently under development which offer constant torque and considerable environmental, reliability and maintainability benefits over internal combustion drive systems. Unfortunately, electric vehicles are range limited, and hybrid electric vehicles still require an onboard Internal Combustion Engine (ICE) to charge the batteries. The purpose of this project is to develop a standardized rapid charger system that can be used on ground support vehicles to increase their availability, and ultimately increase the utility of electric drive systems in ground support equipment and vehicles. Additionally this charging system should be able to charge all types of electric flightline equipment, eliminating different charger configurations for different equipment types. A rapid charge system would eliminate the need for the hybrid ICE and overcome the range limitations inherent in current electric vehicles. This will result in making electric vehicles more suitable for a variety of applications and increasing their utility when compared to conventional ICE vehicles.

PHASE I: Assess feasibility, compare various battery and charging technologies, and identify candidate systems for full evaluation. Current electric ground support equipment and vehicles range in size from electric forklifts with 36 VDC battery packs to aircraft tow tractors with 600 VDC battery packs. A prototype battery pack and charger may be tested in this phase.

PHASE II: Fully research and develop a rapid charging system that can charge the full range of electrically driven material handling equipment and vehicles. The charger may be capable of charging multiple vehicles at the same time. Reliability, maintainability, environmental impact and cost effectiveness of developed technology shall be addressed/ evaluated in this phase.

PHASE III DUAL USE APPLICATIONS: The commercial benefits of this project are tremendous. Rapid charging capability overcomes the current range limitations of electric drive systems. This limitation is the single biggest obstacle in utilizing electric over conventional ICE equipment and vehicles. Replacing conventional internal combustion engines with rapidly charged electric engines has broad applications in the commercial automotive, airline, and marine industries.

REFERENCE: Statement of Objectives (SOO) for Hybrid Electric Tow Tractor

KEYWORDS: Batteries, Rapid Charging, Electric Vehicles

AF99-285 TITLE: Cleaner for Removing Grease and Heavy Soil from Machine Parts

TECHNOLOGY AREA: Environmental Quality/Civil Engineering

OBJECTIVE: Develop a low cost, environmentally and health compliant cleaner for degreasing and cleaning machine parts.

DESCRIPTION: Field level maintenance personnel are required to clean weapon system components, such as aircraft guns and bomb ejector racks, to facilitate various maintenance and inspection procedures. Historically, Methyl Ethyl Ketone (MEK), Stoddard solvent, or highly refined aliphatic hydrocarbon compounds have been used. While effective, these chemicals are either environmentally or health and safety incompatible. Recent cleaners, promoted as 'environmentally friendly' (i.e., water-based), perform poorly and cause flash corrosion. An effective cleaner that can degrease and clean heavily soiled areas in a cost-effective, environmentally compliant, and health and safety compliant manner is required. The weapons systems involved are standard Department of Defense (DoD) weapons listed in the Technical Orders series 11W1 and 11B29 -- applied to high strength steel, corrosion resistant steel, aluminum, composite substrates, and rubber. This cleaner should have no deleterious effects on any of the materials listed.

PHASE I: Assess feasibility; compare various cleaning formulations; consider environmental, health, and safety aspects; and perform tests to validate the formula for full evaluation. A prototype cleaner may be formulated and demonstrated in this phase.

PHASE II:Fully research and formulate a cleaner for controlled testing. Reliability, evaluation of potential damage to aerospace materials, and cost-effectiveness of the developed technology shall be evaluated in this phase.

PHASE III DUAL USE APPLICATIONS: Private industry and government agencies have an aerospace and non-aerospace need for an environmentally friendly cleaner. There is great potential for adapting or adopting the cleaner for use on automobile engines, aircraft engines, or any other heavily soiled machine parts.

REFERENCES:
1) Technical Order 11B29-3-25-2, "Field Maintenance and Overhaul Instructions"
2) Technical Order 11W1-12-10-2, "Intermediate Maintenance 30mm Gun Assembly"
3) ADA221286 [EG&G Idaho Inc.], "Substitution of Wax and Grease Cleaners with Biodegradable Solvents" Phase I Part 4. Wikoff, P.M., Schober, R.K. (et. al), Sep. 1989, 228 p.
4) ADA308321 [Battelle], "Metal-Detergent/Cleaner Compatibility," Hinden, Barry, Jan. 1994, 210 p.

KEYWORDS: Soiled, Cleaner, Formula, Degrease, Bioenvironmental

AF99-286 TITLE: Portable Accumlated Fatigue Damage Inspection and Imaging System

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop a portable inspection/imaging system to identify accumulated fatigue damage prior to crack initiation.

DESCRIPTION: Current force-management policy regarding aircraft structural integrity involves fracture mechanics concepts, nondestructive inspection, and crack repair techniques. The impact of cracks on structural integrity is considered only during the period of crack growth life (i.e., after a crack has initiated.) Therefore, during the life cycle, force-management efforts are applied after accumulated fatigue damage has already manifested as a detectable crack. However, fatigue damage accumulates in service due to cyclic loading. After a lengthy period of incubation, accumulated fatigue damage manifests itself as an incipient fatigue crack, which then grows at a rate proportional to the prevailing service conditions. This period of crack growth is referred to as the crack growth life. The preceding incubation period, in which fatigue damage is accumulating but is not otherwise manifested, is referred to as the crack initiation life. Since the typical crack initiation life period is substantially longer than the crack growth life period, our current force-management approach is constrained by our inability to quantitatively analyze accumulated fatigue damage prior to crack initiation. This topic proposes to develop a concept/technology to identify accumulated fatigue damage prior to crack initiation. Therefore, this proposed concept/technology, by detecting and quantifying accumulated fatigue damage in the crack initiation life period, will allow force-management actions to be employed much sooner and provide the data and understanding that can be employed to extend the life of the pertinent structures well beyond what the current technologies and policies allow. This concept/technology shall be portable and designed primarily for use on high-strength aluminum alloy structures.

PHASE I: Assess feasibility, evaluate, and test candidate concepts and technologies for subsequent engineering development. Develop a prototype, which will demonstrate the capability to empirically and quantitatively identify accumulated fatigue damage in portable packaging.

PHASE II:The concept will be developed to full capability to include the ability to provide quantitative accumulated fatigue damage analysis and near real-time imaging capability. A production prototype will be manufactured and tested by employing DOE criteria to ensure that the capability is fully documented with acceptable levels of precision and accuracy. A conceptual model will be developed to describe the impact of this concept on current force-management policy and techniques.

PHASE III DUAL USE APPLICATIONS: This capability is not only needed by the other DoD services and governmental agencies, such as the FAA and NASA, but also by the commercial aviation industry and the airlines. There is a substantial potential for commercialization if this effort is successful in developing viable technological improvements over the current methodologies.

REFERENCES: "Accumulated Fatigue Damage" Memo, WR-ALC/TIEDM

KEYWORDS: Imaging, Nondestructive Inspection, Accumlated Fatigue Damage

AF99-287 TITLE: Hybrid Electric Power System for Aircraft Loaders

TECHNOLOGY AREA: Surface/Under Surface Vehicles/Ground Vehicles

OBJECTIVE: Develop a hybrid electric power system to provide propulsion power and supply lift and tilt power for aircraft loaders.

DESCRIPTION: Aircraft loaders are conventionally powered by diesel internal combustion engines and utilize hydraulic systems to provide lift and tilt capabilities to the loader deck. Failures of the hydraulic systems are frequent, causing more than half of all loader failures. However, hydraulics have historically been the only choice for applications requiring high-power energy transfer, such as aircraft loaders. Recent developments in high-power electrical controllers indicate the potential for replacing hydraulic systems. This topic proposes to develop a hybrid electrical system for use in aircraft loaders. The system would consist of a hybrid electric power train for vehicle propulsion, with electric motors and actuators capable of meeting lifting requirements. Hybrid power trains for vehicle propulsion have been demonstrated as technically feasible in several DARPA, DOE and Air Force projects. An ancillary benefit of the hybrid drive train is the availability of a large amount of electrical energy. This energy can be applied to the electric motors and actuators for lifting and tilting the loader deck. This hybrid electrical system will provide reliability, maintainability, and environmental benefits over existing hydraulic systems.

PHASE I: Assess feasibility, compare various concepts, and identify candidate systems for full evaluation. A prototype lifting system may be developed in this phase.

PHASE II: Fully research and develop a prototype hybrid electric driven aircraft loader with electrically driven lift and tilt systems. The loader shall be capable of lifting loads up to 25,000 pounds to a height of 18.5 feet. Reliability, maintainability, environmental impact and cost effectiveness of developed technology shall be addressed/evaluated in this phase.

PHASE III DUAL USE APPLICATIONS: Replacing hydraulic systems with high-power electrical systems has application across the commercial sector. Vehicles that could benefit from this technology include commercial aircraft loaders, dump trucks, garbage trucks and any vehicle that uses hydraulics. Fixed hydraulic applications will also benefit from this program.

REFERENCES:
(1) T.O. 36M2-3-33-1, 25K Southwest Loader;
(2) Statement of Objectives for Next Generation Small Loader.

KEYWORDS: Hydraulics, Electric Motors, Hybrid Electric, Electric Actuators

AF99-288 TITLE: New Material for O-Rings and Seals in Halon 1202 Pressurized Systems

TECHNOLOGY AREA: Environmental Quality/Civil Engineering

OBJECTIVE: Develop a low cost, environmentally compliant material for o-rings and seals in pressurized Halon 1202 applications.

DESCRIPTION: Depot level maintenance personnel are required to overhaul fire extinguishers installed in Air Force weapon systems, such as the C-130 and C-141 aircraft, which are pressurized with Halon 1202. The overhaul process, described in TO 13F6-12-3, must have a minimal impact on the environment to comply with the Clean Air Act. The o-rings and seals currently used in the overhaul process are made with materials that deteriorate over time and allow the pressurized Halon 1202 to escape into the atmosphere. A new material needs to be developed that will not deteriorate nor allow the pressurized Halon 1202 to escape.

PHASE I: Assess feasibility, compare various concepts, and perform tests to validate a particular concept for full evaluation. A prototype material may be developed and demonstrated in this phase.

PHASE II: Develop the new material and manufacture prototype o-rings and seals. Reliability, maintainability, evaluation of potential damage to aerospace materials, and cost-effectiveness of the developed technology shall be addressed/evaluated in this phase.

PHASE III DUAL USE APPLICATIONS: Private industry and other government agencies have both an aerospace and non-aerospace need for this material. This technology will be useful in the commercial sector for containing and controlling pressurized Halon 1202. Potential applications include commercial and private aircraft, ship/boat applications, or any other pressurized system using Halon 1202.

REFERENCES:

1) Technical Order 13F6-12-3, "Overhaul With Parts Breakdown Aircraft Fire Extinguisher,"
2) Clean Air Act
3) Clean Air Act Amendments of 1990
4) Georgia Rules for Air Quality

KEYWORDS: Gases, Seals, O-Rings, Halon 1202, Pressurized, Clean Air Act

AF99-290 TITLE: Java Based Automatic Test System and Test Program Set Environment

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop a TPS using a platform independent test executive/resource controller and test development environment.

DESCRIPTION: The Air Force spends millions of dollars each year rehosting older TPSs to newer, more modernized ATSs. Rehosting of TPSs is inevitable and is becoming more frequent, since the average supportable life of newer ATSs is now less than 7 years. ATS technologies are changing at an exponential rate, making test equipment obsolete much quicker. One of the primary factors in TPS rehost costs is platform dependence. During the rehost process, this platform dependency often forces the AF/DoD to search out emulation techniques that provide a degree of TPS transferability but add additional maintenance complexity. With the advent of the JAVA based programming language, TPSs can now be written and developed in processor independent ways, elevating the need for translators. This will also allow TPSs to be migrated between different platforms, given that both systems have a similar instrument complement and interface connection. This idea of using JAVA in both the ATS test executive and resource controller within a TPS can yield significant cost savings, especially since the AF currently has no standardized software test platform.

PHASE I: Develop a JAVA-based ATS and runtime/platform independent TPS. This phase will include the development of a comprehensive JAVA ATS software architecture and a process for using JAVA in both ATS control and TPS development. The architecture and JAVA class structure for test must be adequately documented, to include as a minimum the architecture and test class object models, IDL or equivalent specifications for the JAVA objects, and explanatory text. Phase I should also include a demonstration of a simple JAVA-based ATS using the defined software technology and architecture to show the concepts of utilizing a TPS across similar test platforms.

PHASE II:Develop a full-up prototype which will include an ATS running JAVA based code and a medium complexity mixed signal TPS developed to prove the concept. JAVA based TPSs will also need to be benchmarked against other commercially available TPS development toolsets, comparing performance, maintainability, reusability and rehostability of the TPSs.

PHASE III DUAL USE APPLICATIONS: This project has the potential to revolutionize the commercial ATS market as we currently know it. The standardization of ATS and TPS software will be quickly embraced by the commercial airline industry. Successful demonstration of the prototype would serve as a springboard for other commercial developers to market similar products.

REFERENCES:
1) Longuemare Memo, dated 29 April 94, "DoD Policy for Automatic Test Systems" SECDEF Memorandum, dated 29 June 94, "Specifications and Standards - A New Way of Doing Business"
2) USD (A&T) Memorandum, dated 29 November 94, "Acquisition of Weapons Systems Electronics Using Open Systems Specifications and Standards"

KEYWORDS: JAVA, Software Reuse, Software Rehost, Test Program Sets, Automatic Test Systems

AF99-291 TITLE: A Five-Function PCMCIA/CardBUS Device for Diagnostic Testing

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop a five-function PCMCIA/CardBUS device to include wireless communication, Fortezza Security, Ethernet, IEEE-488, and MIL-STD-1553 capability.

DESCRIPTION: The Air Force has a growing need for a downsized test capability using commercial technology. To further exploit existing PCMCIA/CardBUS technology for diagnostic testing, the Air Force desires to create a five-function PCMCIA/CardBUS device that can operate in a subnotebook computer or palmtop based Portable Digital Assistant (PDA) type device. The combination of these functions will allow for 'wireless' communication with both the weapon system and its associated support equipment (including Automatic Test Equipment (ATE)) in a secure environment. The Five-Function PCMCIA/CardBUS device will eliminate the need for bulky cables and nonstandard hardware interfaces at the organizational (flight-line) level. In addition, wireless communication will allow support equipment to communicate with the base LAN for other information including digital technical orders, test procedures, and aircraft Operation Flight Programs (OFPs). The user will be able to use Ethernet connectivity or utilize the built-in modem in most PDAs and subnotebooks for communication when out of wireless range. The incorporation of the MIL-STD-1553 and IEEE-488 protocols allows the device to access both aircraft Built-In-Test (BIT) and Automatic Test System (ATS) functions. Given the capability of commercial PDA devices which are based on Window CE platform, the compact PCMCIA diagnostic capability, combined with a hand held computer, provides wide range of connectivity options and a significant reduction in logistics footprint.

PHASE I: Phase I would consist of packaging research and the use of custom integrated circuits to meet the PCMCIA/CardBUS size requirement. Given the functional complexity of the device and its need for some ancillary cables, significant research would be required to ensure all the capability of the device could be brought out externally. In addition, power requirements will have to be investigated and identified to ensure a device could function within a reasonable period on batteries.

PHASE II: Development of a full-scale prototype that would include a demonstration of the device being utilized on a weapon system. The speed would need to be benchmarked against other PCMCIA/CardBUS devices and functions to ensure its performance.

PHASE III DUAL USE APPLICATIONS: Many commercial computer systems already incorporate dual PCMCIA/CardBUS slots, the potential to downsize current ATS test technology into laptops would revolutionize ATS organizational (flight-line) maintenance as we know it today. The device will also be quickly embraced by the commercial airline industry since the technology would be directly applicable. Successful demonstration of the prototype will serve as a springboard for other commercial developers to market similar products and enhance the density of PCMCIA/CardBUS devices.

REFERENCES: USD (A&T) Memorandum, dated 29 November 94, "Acquisition of Weapons Systems Electronics Using Open Systems Specifications and Standards"

KEYWORDS: PCMCIA, CardBUS, Wireless, Fortezza, Diagnostics, Automatic Test Systems

AF99-292 TITLE: Wireless Interface for Automatic Test Systems

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Incorporate wireless communication technology into a computer based ATS for data exchange.

DESCRIPTION: In military operations, a significant portion of the logistics footprint is the cabling that connects the automatic test equipment to the weapon system or component under test. Many times, modifications and upgrades to weapon systems will require a change in the physical interface between the ATS and the unit under test. A single test station may require many sets of cables to test all versions of a given weapon system. Although some effort has been made to specify standard interfaces, an innovative approach is to bypass the use of cables and implement wireless communication for data exchange. This technology could be applied to legacy systems via receiver and transmitter modules designed for the existing interfaces, and it could also be built into new development items.

PHASE I: The initial phase will evaluate existing wireless communication technology, and identify appropriate option(s). The type of information to be transmitted via the interface, i.e. test programs, diagnostic routines, self-test data, etc., will be identified. A specification for receiver and transmitter modules will be developed to create a wireless interface for the ATS. The research should also consider data integrity and security issues.

PHASE II: Develop a wireless interface prototype, utilizing commercial-off-the-shelf items wherever possible. This implementation will be targeted at a specific weapon system.

PHASE III DUAL USE APPLICATIONS: This project has a potential impact on all users of ATSs, both military and commercial. Successful demonstration of the prototype will allow proliferation within the DoD, and promote commercial competition to market similar products.

REFERENCES: SD (A&T) Memorandum, dated 29 November 94, "Acquisition of Weapons Systems Electronics Using Open Systems Specifications and Standards"

KEYWORDS: Receiver, Transmitter, Wireless Communication, Automatic Test Systems

AF99-293 TITLE: High Bandwidth Digital Rotating Interface (HI-DRI)

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop a digital interface capable of reliably passing multiple channels of very high bandwidth digital data across a continuously rotating axis.

DESCRIPTION: Current generation weapon system sensors are using detector arrays that generate digital image data at a rate of 100 to 250 megabits per second. These new sensor systems must be tested on rotating instrumentation platforms such as remotely operated turret systems or multi-axis flight tables. Current mechanisms for digital data transfer across these rotating interfaces generally utilize mechanical slip ring assemblies, which are limited to a data transfer rate of 10 to 50 megabits per second. A new capability must be developed to match the sensor data transfer rate across the rotating axes of these test platforms. This high bandwidth digital rotating interface must be able to handle multiple channels of high bit rate data and must have the design flexibility to be re-packaged into various mechanical shapes so that in can be utilized on a variety of test platforms. Anticipated requirements are:

a. Single channel data rates up to 250 megabits/sec
b. A minimum of 32 channels in a single assembly
c. Rotation rates up to 60 rpm, continuously
d. Adaptability to a variety of platforms including turret Systems, flight tables, etc.

PHASE I: Evaluate the feasibility of transmitting high bandwidth digital data across a rotating axis. Perform design approach trade-offs, define all hardware/software requirements, and prepare a validation test plan.

PHASE II: Design, develop and produce a prototype HI-DRI unit that meets the system requirements. Document performance capabilities, test results, and potential design variations to accommodate different mechanical shapes and test applications.

PHASE III DUAL USE APPLICATIONS: Transportation, emergency/medical, and manufacturing industries; any industry using remote sensing and robotics.

REFERENCES:

1) Ames, Gregory H. and Morency, Roger L., Passive, Multi-Channel Fiber Optic Rotary Joint Assembly, AD-D017 353, Dec 1994 PAT-APPL-151 396, PATENT 5 371 814
2) Ames, Gregory H., Method Providing Optimum Optical Trains Alignment in a Passive Multi-Channel Fiber Optic Rotary Joint, AD-D016 125, Dec 1993 PAT-APPL-956 328 PATENT 5 271076.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Digital, Data Transfer, High Bandwidth, Instrumentation, Rotary Interface

AF99-294 TITLE: Common Real-Time/Postmission Data System

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop a Personal Computer (PC)- based capability to capture, process, display, record and play back synchronized data from multiple real-time test mission sources.

DESCRIPTION: The Air Force Test and Evaluation (T&E) community requires a new PC-based (Windows NT) capability to provide both synchronized real-time play and postmission playback of test mission data, including telemetry, video/audio, and Time Space Position Information (TSPI). The ability to gather, display, record, process and play back these multiple sources of data via a single integrated application will improve T&E analysis and reporting capabilities and reduce the cost and time associated with weapon system evaluation. More specifically, this application is envisioned to provide the following capabilities/ characteristics: (1) importing of the various data sources; (2) encoding of video signals; (3) generic statistical analysis features for data parameters; (4) 2D/3D/polar/stripchart plotting; (5) screen building capabilities for data visualization; (6) 3D flight visualization/control with range map overlays; (7) VCR type controls and a flexible setup capability with recall feature; and (8) automatic report generation with audio annotation capability that allows the operator to select or filter data to be included in a report. Key technical challenges for this effort include: synchronization of all data sources, and providing the ability to play back that captured real-time data with identical displays in postmission analysis.

PHASE I: Research appropriate technologies, define innovative ideas/approaches, perform trade-off analysis and determine hardware/ software requirements. Prepare validation test plan and document results.

PHASE II: Design, develop, produce and integrate prototype advanced multi-source test mission synchronized data playback system. Perform validation testing and document results.

PHASE III DUAL USE APPLICATIONS: Commercial applications include medical and commercial aviation use. For examples: (1) video of operations along with recordings of patients vital signs could be synchronized and then used to evaluate the operation or be used for training purposes; (2) cockpit video could be synchronized with recordings of cockpit data parameters to replay accidents and support training.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: TSPI Data, Telemetry, Synchronized Mission Playback of Video

AF99-295 TITLE: Munitions Lethality Computational Framework

TECHNOLOGY AREA: Modeling and Simulation (M&S)

OBJECTIVE: Develop a physics-based computational framework to support Air Force weapon systems testing, evaluation, and analysis.

DESCRIPTION: All Air Force weapon systems must be tested to assess their lethality and effectiveness against many classes of targets. Target classes generally include fixed structures (above and below ground), enemy air defense sites, and a variety of mobile ground and aerial targets. A wide array of Test and Evaluation (T&E) is required throughout the life cycle of a weapon system, including: research and measurement, digital and hardware-in-the-loop Modeling and Simulation (M&S), developmental and live fire validation testing, and operational and sustainment testing. The cost of T&E can be substantially reduced by decreasing the number of real world test events and increasing the use of M&S through the use of realistic physics-based analysis frameworks. This shift towards testing through M&S, however, is viable only when the computational framework is sophisticated enough to predict real world interaction and related phenomena. Existing models fall short in satisfying the required level of fidelity. It is believed that the key to achieving the desired computational realism is through iterative refinement of the physics-based model, based on input of actual test results and predictive comparisons. Innovative concepts are needed to develop the analytical and computational framework necessary to accurately model the physics involved in the highly dynamic interaction between weapon and target. Output results should include critical elements, such as specific target geometry versus time and resulting physical and functional damage caused by attacks on the various classes of targets. The most urgent need is to support evaluation of large and small conventional munitions with blast/fragmentation warheads, smaller smarter munitions with sophisticated terminal guidance, and the emerging class of directed energy weapons versus above ground and mobile targets. There is also significant opportunity for unification of the many different and competing computational architectures currently in use. This framework must include provisions for physics-based modeling of detonation, blast, fragmentation, incendiary, directed energy, airborne particulate dispersion, and other effects. The framework should accept test data for calibration of lethality models used to predict phenomenology, live fire, and operational test results. The framework must be consistent with the DoD High Level Architecture (HLA) requirements for digital modeling and simulation and it should be expandable to support an improved understanding of potential new lethal effects against all targets of military worth.

PHASE I: Define innovative ideas/concepts/techniques for developing a Munitions Lethality Computational Framework and evaluate candidate approaches. Develop and document hardware/ software requirements and verification/ validation test plans.

PHASE II:Design, develop and produce a prototype Munitions Lethality Computational Framework. Demonstrate/ document applicable models to predict phenomenology, developmental, Live Fire, and operational test results.

PHASE III DUAL USE APPLICATIONS: Commercial applications include analysis of space debris impact on commercial satellites and modeling and assessment of potential terrorist acts against commercial assets.

REFERENCES:

1) An Analysis Comparison Using the Vulnerability Analysis for Surface Targets (VAST) Computer Code and the Computation of Vulnerability Analysis Computation of Vulnerable Area and Repair Time (COVART III) Computer Code, ARL-MR-341, DTIC Ref AD-A321 736

2) Improved Fragmentation Algorithms for Debris Environments, DTIC Ref AD-A314 502

3) A guide to FASTGEN Target Geometric Modeling, JTCG/AS-92-SM-25, DTIC Ref AD-A273 171

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Lethality, Effectiveness, Fragmentation, Vulnerability, Explosive-Blast, Physics-Based Models, Conventional Munitions, Target Geometric Modeling

AF99-297 TITLE: Object Oriented Damage Prediction and Target Vulnerability

TECHNOLOGY AREA: Modeling and Simulation (M&S)

OBJECTIVE: Develop a state-of-the-art methodology and model for predicting target damage from warhead detonation using Commercial Off-The-Shelf (COTS) object-oriented software applications.

DESCRIPTION: Current methods and models used for estimating target vulnerability to conventional munitions attack are no longer adequate for providing the accuracy and event visualization required today. Current damage assessment prediction models were designed and implemented using programming languages that are only capable of using simplistic point burst assumptions and expected value outcomes. Current models can not comply with the DoD regulation for all models, supporting major program decision milestones, to pass a vigorous Verification, Validation and Accreditation (VV&A). Innovative concepts are needed to increase the utility of damage prediction and vulnerability estimation models. Using state-of-the-art, object-oriented languages (like C++) and cutting edge graphical user interface design techniques, the process and procedures for accurately predicting target damage can be enhanced dramatically. New target damage products must be easily visualized and seamlessly integrated into higher level campaign and theater models. This new modeling capability, offering use of either Monte Carlo-based or deterministic prediction methodology, will support the model-test-model approach that is critical to today's streamlined, acquisition process. The new process must: (1) be Target Geometry Model (TGM) independent; (2) allow for more flexibility in various modes of operation (single burst point at a specified location, multiple burst points at specified locations, multiple burst points forming a specified grid, and multiple/ random burst points from a specified distribution); (3) calculate and output both vulnerable areas and probabilities of kill given a hit (Pk|h); (4) employ modern, object-oriented fault tree analysis methods; and (5) eliminate the need for "feeder models." The new modeling process must be modular for easy incorporation of new test information, new and novel kill mechanisms, and graphic output needs. Finally, this new process should run on both PC- based Windows applications or UNIX operating systems.

It is emphasized that this newly developed model must be capable of simultaneously supporting diverse analysis requirements of Analysis of Alternative studies, Congressionally mandated Live Fire Test and Evaluation (LFT&E), weapon trade and warhead optimization study for rapidly evolving smart munitions development programs. As such, the current legacy codes used by Eglin
over that past three decades has provided absolutely critical milestone decision data for programs such as the JSOW/BLU-97, Sensor Fused Weapon (Baseline and P3I), GAU-8 gun, Maverick, LOCAAS and HARM through and including validation versus LFT&E field trial results. Generally, methodology developed by the JTCG/ME applies to inventory munitions and is not applicable to this
rapidly evolving state-of-the-art smart munitions development concepts and programs, many of which involve new and exotic kill mechanisms. This is particularly true of comparisions to LFT&E results where JMEM methods based on MAE and target vulnerable area are wholly inadequate to the analysis requirements.

PHASE I: Research current technologies, determine and document current model deficiencies, define innovative concepts/approaches, perform trade-off analysis to determine best value concept. Develop and document hardware/ software requirements and prepare VV&A test plan.

PHASE II: Design, develop and implement prototype vulnerability assessment model with applicable hardware and software. Verify and validate the system performance through realistic testing and demonstration; document system and results.

PHASE III DUAL USE APPLICATIONS: FBI and FEMA use predictive models of structural damage to buildings subjected to terrorist attack or natural disaster. Fault tree analysis methods of failure modes are applicable public conveyance systems, industrial machinery, and commercial space vehicles/ satellites.

REFERENCES:
1) Bruenning and Grove, Point Burst Damage Assessment Model (PDAM) Users Manual, AFATL Contract C08635-83-C-0010, Dec 1983
2)Bruenning, Fleming, and Becker, PDAM 95, System Description AFDTC Contract F08635-91-C-0002, Jan 1998 3) Improved Fragmentation Algorithms for Debris Environments, DNA TR-96-20, DTIC Ref AD-A314 502 4) A guide to FASTGEN Target Geometric Modeling, JTCG/AS-92-SM-25, DTIC Ref AD-A273 171.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Model, Prediction, Assessment, Monte Carlo, Deterministic, Vulnerability, Probability of Kill, Target Geometry Models, Conventional Munitions

AF99-298 TITLE: Mission Level Modeling and Simulation Capability

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop a capability to transfer and utilize mission planning data to model and simulate mission level weapon system encounters in an existing Installed Systems Test Facility (ISTF).

DESCRIPTION: The Test and Evaluation (T&E) of current and future Air Force weapon systems require the capability of hardware-in-the-loop Modeling and Simulation (M&S) at the Mission ("many-on-many") level. Current M&S capabilities within the existing ISTF at Eglin AFB, Florida, is limited to the engagement (one-on-one) level. Innovative solutions are needed to extend these capabilities to accommodate mission level M&S. Mission level models must access the same mission data currently provided to operational aircraft and weapons systems through various mission planning tools, such as the current Air Force Mission Support System (AFMSS) or the future Joint Mission Planning System (JMPS). Data from these mission planning tools, such as multiple flight path scenarios, terrain data, environmental conditions, etc., must be integrated into the existing ISTF simulation models. The objective of this new capability would be to capture all appropriate mission planning data from the various data sources and transfer devices and to transfer and exercise that data in existing engagement simulations. The research should focus on the application to command, control and communications environments. Pertinent considerations include, but are not limited to, synchronization, correlation and registration, of hardware and software from differing planning tool architectures.

PHASE I: Research appropriate technologies, perform trade-off analysis, and define the hardware and software requirements needed to transfer and integrate mission planning data from multiple sources and planning tools into the existing engagement simulations. Document results and prepare validation test plan.

PHASE II:Design, develop, produce and integrate a prototype Mission Level M&S capability within the existing ISTF. Demonstrate and validate a mission level model using data from a mission planning system (such as AFMSS). Validate and document the results and the method of operation.

PHASE III DUAL USE APPLICATIONS: The commercial space and the advanced automotive industries will utilize M&S capability for mission planning. Examples include development of mission planning tools for reusable launch vehicles or deployment of a national automated highway system.

REFERENCES: Deis, Michael, PRIMES Users Manual, May 1998.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Command, Mission Level Model, Engagement Level Model, Mission Planning Tools, Modeling and Simulation, Installed Systems Test Facility, Control and Communications (C3)

AF99-299 TITLE: Off-board Targeting Data Link Simulation Capability

TECHNOLOGY AREA: Command, Control, and Communications (C3)

OBJECTIVE: Develop a system to simulate the data link functions required for various off-board targeting applications and integrate this system into an existing Installed Systems Test Facility (ISTF).

DESCRIPTION: Off-board targeting is the concept of passing digital target information from one weapon system platform to another through use of data links. For example, one aircraft might provide target identification and location information directly to another aircraft through a data link without pilot communication. Future aerial and ground weapons platforms will incorporate cooperative targeting and automatic vehicle-to-vehicle information exchange to maximize mission effectiveness by implementing a variety of data link functions. A need exists to be able to model and simulate the actual data link functions and the information transfer within an existing ISTF at Eglin AFB, Florida. The capabilities of the existing facility include target generation simulation. The objective of this topic is to replicate or simulate the data link functions between multiple platforms (i.e., aircraft, mobile ground vehicles, ground stations, etc.) and to integrate this new capability into the existing ISTF capability. Pertinent considerations include, but, are not limited to: identification of all existing command, control and communications (C3) data links; accuracy requirements for off-board data exchange applications; and integration requirements for providing a common coordinateREFERENCE system for airborne, ground, and space sensor data link simulation algorithms.

PHASE I: Research applicable technologies, perform trade-off analysis, and define the hardware and software requirements needed to simulate realistic off-board targeting data links. Determine the integration requirements to incorporate the capability into the existing ISTF. Document results and prepare validation test plans.

PHASE II: Design, develop, produce and integrate a prototype system that simulates real world data link functions, using a common data link coordinateREFERENCE system, within the simulated environment of the existing ISTF. Validate and document the results and the method of operation.

PHASE III DUAL USE APPLICATION: The commercial aviation and the intelligent automotive industry will use cooperative data link systems. Examples are foul weather navigation for commercial aviation and coordinated control of vehicle braking on automated highway systems.

REFERENCES: Kirchner, Rick, Fincher, Ted, and Armogida, Frank, Rapid Targeting and Real-Time Response: The Critical Links for Effective Use of Combined Intelligence Products In Combat Operations, XB-NAWC-WPNS, AD-A318 888, Dec 1996.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Command, Data Links, Off-Board Targeting, Cooperative Systems, Coordinated Control, Control and Communications (C3), Installed Systems Test Facility

AF99-300 TITLE: Bit Rate Agile Onboard Telemetry Formatter

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop onboard data cycle map (DCM) formatter that can generate DCMs of any bit rate.

DESCRIPTION: Frequency spectrum availability for use in telemetry is decreasing [1] and hardware to support efficient use of this spectrum needs to be developed. A significant waste of this spectrum is caused by onboard DCM formatters, which restrict the bit rates of the generated DCMs. A DCM formatter providing full control of bit rate would allow for the transmission of exactly what data are required. Further waste is incurred through word fill caused by the use of fixed word sizes in DCMs. Thus, the developed system should also support mixed word lengths. That is, different word lengths should be allowed within the same DCM. The developed formatter should be flexible and programmable enough to be used with various existing onboard instrumentation systems (e.g., AATIS, CAIS, etc.). That is, the formatter should not be limited to one proprietary instrumentation system. The formatter must be small and ruggedized in order to meet onboard requirements. Available format bit rates should exceed bit rates specified by existing systems and standards. Word lengths of 1 to 64 bits should be available. This project should not present a theoretical challenge. The emphasis here is on applying theory and on resolving the technical aspects of implementing a versatile piece of hardware. The formatter should provide technical agility and platform independence. It should be designed on open architecture and plug and play concepts.

PHASE I: Analyze feasibility of developing a bit rate agile airborne instrumentation controller/formatter, which can interoperate with existing airborne instrumentation systems. Develop preliminary designs for such systems. Provide a final report of analysis and recommendations.

PHASE II: Build and test a demonstration system. Validate bit rate agility, word length agility, and bandwidth savings in ground based and airborne tests at the Air Force Flight Test Center, Edwards AFB, California.

PHASE III DUAL USE APPLICATIONS: Any user of telemetry is a potential customer. The requirement for efficient use of telemetry bandwidth is being driven by both an increase in the amount of data to be transmitted and a decrease in spectrum availability. Further, the commercial uses of telemetry are expanding. The need for agile telemetry systems is just starting to be discussed and a company developing such a system has the potential of becoming a leader in an expanding market.

REFERENCES:
1) Timothy A. Chalfant, Erwin H. Straehley and Earl R. Switzer, "Advanced Ranged Telemetry (ARTM) Preparing for a New Generation of Telemetry," Proceedings of the International Telemetering Conference (ITC), Vol. XXXII, 1996 paper number 96-24-2 2) Charles H. Jones and Lee S. Gardner, "Complexity of PCM Formatting," Proceedings of the International Telemetering Conference (ITC), Vol. XXXIII, 1997 paper number 97-10-5.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Bandwidth, Telemetry, Bit Rate Agility, Frequency Spectrum, Test Instrumentation

AF99-301 TITLE: Flutter Suppression System Test Techniques

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop a safe and efficient approach for conducting flight test envelope expansion on aircraft that utilize a flutter suppression system to stabilize an aircraft that is inherently structural dynamically unstable within the aircraft's operational envelope.

DESCRIPTION: There is an ongoing effort to reduce the structural weight of aircraft in order to enhance performance characteristics. The weight reduction will likely result in airframes that are not as stiff, which will increase the chances of inherent structural dynamic instabilities. One method of improving aeroelastic stability characteristics is to utilize a flutter suppression system. Flutter suppression systems have already been demonstrated at the government laboratories and will undoubtedly be incorporated on future aircraft. An aircraft that utilizes an active flutter suppression system will have dramatically different instability characteristics than a conventional aircraft. Using traditional methods to flight test this type of aircraft will increase risk, and could be completely ineffective. Therefore it is necessary to rethink the way flutter flight testing should be done for aircraft with flutter suppression systems. The conditions that lead to a flutter suppression system being incapable of stabilizing the aircraft need to be identified. New criteria need to be produced to anticipate those conditions before instabilities occur. Visualizations techniques need to be developed so that the flight test engineer can easily identify potential instabilities and take appropriate action. A program needs to be produced that incorporates these new techniques into a single package that can easily be incorporated into the control room.

PHASE I: Study the conditions that lead to flutter suppression systems being incapable of stabilizing the aircraft and identify the indicators that instabilities are impending. Develop an efficient method to expand the flight envelope of an aircraft equipped with a flutter suppression system and go-no go knock it off criteria. Report all findings.

PHASE II:Develop a software program to execute the envelope expansion plan and demonstrate its ability to anticipate conditions where a flutter suppression system will be unable to stabilize the aircraft.

PHASE III DUAL USE APPLICATIONS: In time flutter suppression systems will also be incorporated into commercial aircraft and the same type of build up will be necessary. Flutter suppression systems are a small facet of the larger field of controls. This technology could be used to anticipate failures in other controls applications.

Notice: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Flutter, Controls, Aeroelastic, Active Damping, Flutter Suppression

AF99-302 TITLE: Instrumentation Network Architecture

TECHNOLOGY AREA: Electronics

OBJECTIVE: Develop high performance instrumentation network architecture.

DESCRIPTION: As test articles become more complex, their testing and data acquisition requirements are spiraling upward. These new data acquisition requirements span numerous areas such as performance, upgradeability, cost, and versatility. Merely upgrading these present systems is not a viable path to meet future requirements. A new approach that will allow the timely insertion of leading edge technology is crucial to meet ever increasing demands. To cost-effectively meet this need, an instrumentation network that is capable, versatile, and open is required. The architecture must support laboratory, cargo aircraft, fighter aircraft, helicopter, and modeling and simulation environments. The communication protocol must take into account data acquisition, unit programming, measurement processing and display, telemetry, and recording capabilities. In addition, the architecture must be flexible to allow real-time changes in both data acquisition and distribution. This includes integration of frequency spectrum efficient technologies developed to support the Advanced Range Telemetry (ARTM) program.

PHASE I: Research network architecture beyond current capability in terms of technical performance characteristics and implementation cost impact. Select and propose one or more specific methods for demonstration.

PHASE II: Build and test a demonstration system. Validate performance and characteristics in laboratory or ground based open-air-tests and support flight trials at the Air Force Flight Test Center, Edwards AFB, California.

PHASE III DUAL USE APPLICATIONS: The commercial application of this project would extend to commercial airliner testing, automotive testing, product manufacturing, and modeling and simulation.

REFERENCES:
1) "Range Telemetry Improvement & Modernization" by Tim Chalfant and Chuck Irving. Published in the 1997 International Telemetering Conference (ITC) proceedings, volume XXXIII. For more information, contact the ARTM Joint Program Office, Chuck Irving, (805) 275-4055, Edwards AFB, CA 93524-8300
2) "Smart Sensor Networked System" by Fernando Gen-Kuoing and Alex Karolys (Endevco). Published in the 1997 ITC proceedings, volume XXXIII 3) Telemetry Standards, IRIG Standard 106-96, May 1996, Secretariat, Range Commanders Council, U.S. Army White Sands Missile Range, New Mexico 88002-5110.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Network, Data Telemetry, Data Processing, Instrumentation, Communication Protocol

AF99-305 TITLE: Parameter Identification of Short Takeoff and Vertical Landing (STOVL) Aerodynamic Characteristics during Hovering and Transition from/to Wing Borne

TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: Extend parameter identification techniques to STOVL aircraft during hovering and transition from/to wing borne flight.

DESCRIPTION: Parameter estimation techniques have been used extensively to identify in-flight aerodynamics in support of numerous flight test programs with a high degree of success. Because of the importance of the aerodynamics regarding the flying qualities, it is important to determine the accuracy of the predicted aerodynamic model, and devise strategies for correcting it online. During hovering and transition from/to wing borne flight, the dynamics of STOVL aircraft and the corresponding aerodynamic models are highly non-linear, stochastic, and a strong function of height-above-ground and forward speed, which makes the parameter identification a difficult task. Successful application of parameter estimation techniques to this regime needs to be demonstrated.

There are several advantages to the AF in improving the accuracy of aerodynamic models from flight tests: 1) Necessary to understand aircraft flying qualities; 2) Necessary when flight control system deficiencies must be corrected; 3) Used to validate contractor prediction methods; 4) Used to reduce flight test risks through more accurate predictions of envelope expansion test points; 5) Necessary to increase the usefulness of the flight test simulator during the test program; 6) Necessary when tests are to be standardized to a selected aircraft configuration and flight condition; and 7) A properly validated model can reduce program risk by allowing more accurate predictions of operational effectiveness and suitability.

This technology has direct application to the Joint Strike Fighter (JSF). The JSF will be relying heavily on modeling and simulation during both the program definition and risk reduction, and the engineering, manufacturing, and development phases of the program. A properly validated model can reduce program risk by allowing efficient correction of deficiencies by avoiding the fly-fix-fly method.

PHASE I: Develop accurate model structure determination and aerodynamic parameter identification techniques for STOVL aircraft in operating in ground effect. Demonstrate the performance of the algorithm using 6 degree-of-freedom (DOF) simulations.

PHASE II: Develop, test and deliver software for complete identification of STOVL aircraft aerodynamics from flight test data.

PHASE III DUAL USE APPLICATIONS: Potential commercial applications of the work proposed in Phase II are: 1. Vibration suppression for military aircraft, helicopters, rotocraft, commercial aircraft, ships and submarines. 2. Ground vibration testing for aerospace and ground vehicles, including automobiles. 3. Vibration monitoring/diagnostics for mechanical equipment, off-shore drilling platforms, bridges and high-rise buildings. 4. Industrial process identification.

REFERENCES: Klein, Vladislav: Determination of Airplane Model Structure From Flight Data Using Splines and Stepwise Regression, NASA Technical Paper 2126, 1983.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Flight Test, Spline Models, Aerodynamic Modeling, Stability and Control, Parameter Identification, Short Takeoff and Vertical Landing (STOVL)

AF99-306 TITLE: Spectrally Efficient Target Imaging (SETI)

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop an advanced capability that enhances video images in real-time to be able to define targets against backgrounds of varying contrast and varying weather conditions including clouds, wind, haze, airborne particulate, and fog.

DESCRIPTION: Aircraft and munitions tracking at the Air Force Flight Test Center (AFFTC), Edwards AFB, California, and at other Department of Defense (DoD) ranges is becoming increasingly challenging. As the population of the surrounding areas of DoD test ranges increases, more pollution is deposited in the air resulting in increased airborne particulate, haze, and other phenomenon that reduce visibility. In addition to the pollution, aircraft and munitions are moving at a higher velocity, optical turbulence caused by surface heating causes severe image degradation, clouds, wind, fog, and background clutter are present, and some of the targets are stealthy. There are commercial, off-the-shelf (COTS) solutions to this problem; however, they are cost prohibitive. Infrared cameras typically cost tens of thousands of dollars, and the cost of range-gated laser camera systems is even more. The goal of the AFFTC is to develop an inexpensive, remotely operated, capability using spectral imaging that enhances video images in real time to be able to define targets against backgrounds of varying contrast and varying weather conditions including clouds, wind, haze, airborne particulate, and fog. This capability has to be more affordable than the devices already mentioned.

PHASE I: Conduct a feasibility analysis and prepare a recommended system design. Submit a final report covering the analysis results and the system design.

PHASE II: Build a proof of concept system and demonstrate its operation at the (AFFTC). Submit a final report on results of the demonstration.

PHASE III DUAL USE APPLICATIONS : Satellite surveillance, Commercial Photography, Motion Picture Industry, Law Enforcement Surveillance

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: IR Cameras, Air Pollution, Spectral Imagers, Optical Tracking, Image Enhancement, Electronic Optical Tunable Filter

AF99-307 TITLE: Common Test Instrumentation Kit

TECHNOLOGY AREA: Conventional weapons

OBJECTIVE: Develop a TIK capable of application on a wide range of weapon systems.

DESCRIPTION: Test Instrumentation Kits (TIKs) are installed in a large variety of weapon systems to collect, encode, and transmit vehicle test telemetry data. The current approach to design and testing of a TIK is to develop a unique TIK for each individual weapon system. Wide-ranging requirements for throughput, power, encryption, and physical space limitations available for the TIK have resulted in the TIK design being incorporated into the system design process resulting in long-term design cycles. Extensive design and qualification testing are required for each unique TIK using today's methods. This approach has resulted in separate TIKs for the JDAM (Joint Direct Attack Munitions), JASSM, AGM-65, MALD (Miniature Air Launched Decoy), AGM-130, and AGM-142 systems, with little or no interchangeability or inoperability.

This effort should provide the engineering, research, and development necessary to standardize a TIK suited for wide-ranging applications in future weapons systems (such as MALD and LOCAAS). The baseline design may offer several options to meet the widest possible range of test vehicles, considering retrofit of existing TIK designs as a possibility. The effort will perform verification testing to measured or calculated extreme environmental conditions rather than the minimum necessary for a specific program. Innovative design and packaging is essential. Guidelines for telemetry transmitting, receiving, and signal processing requirements should be taken from IRIG-STANDARD-106-96, Telemetry Standards. System specifications, component specifications, drawings, and test procedures will be part of this effort.

PHASE I: Define hardware and software system requirements, research appropriate technologies for the best design baseline, and determine the potential life cycle (design, development, and logistics support) cost savings associated with the use of a standardized TIK on a new start program. Develop system specifications and verification test plans.

PHASE II:Design, develop and produce a limited number of flight worthy prototype TIKs. Validate the system through verification testing and document results.

PHASE III DUAL USE APPLICATIONS: Industries such as oil and mining, commercial aviation and transportation have potential uses for this standard, highly reliable communications package capable of performing many functions remotely.

REFERENCES: IRIG-STANDARD-106-96, Telemetry Standards

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: TIK, Global Positioning Systems (GPS)

AF99-308 TITLE: Atom or Molecular Technology for Testing Electronic Circuits

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop a hardware/software method to improve test and failure detection capability using atom or molecular technology for Air Force systems.

DESCRIPTION: Theoretical methods to verify hardware functionality and determine defective components have serious limitations. These limitations are very costly and have the adverse effect of equipment life-cycle reduction. New approaches for test and failure detection utilizing technologies at the atomic or molecular level must be created to meet the testing requirements of new equipment and systems throughout the complete development life cycle. Understanding of hardware functionality has progressed to an atomic or molecular level. Atom or molecular technology is the science of visualizing, analyzing, controlling, scanning, and applying technologies at the atomic or molecular level. Technologies for identifying chemical categories of observing and measuring molecules or organic polymers on a surface or substrate, or in three-dimensional space using a mechanical probe, electron beam, or laser, (etc.) is the primary objective of this topic. Detection of faulty circuits at this level of surveillance is the primary objective of atom or molecular technology. Atom or molecular technology surveillance in a software controlled stimulus/sensor enviroment is a key issue. If this type of technology can be exploited for test, it could save on repair and equipment costs. Technologies need to be explored which can perceive hardware integrity at the molecular or atomic level. Techniques to perform this type of testing are needed to lower costs and improve fault-detection. Atom technology is of inter- and trans-disciplinary nature, crossing over boundaries of existing technological categories, and constitutes a generic technology common to various industrial fields, such as new materials, electronics, biotechnology and chemistry. An extensive secondary effect may be expected from this important research field.

PHASE I: Conduct research and develop procedures for candidate atom or molecular technologies to test and diagnose failures in Air Force hardware. Document application criteria of this technology to current established processes.

PHASE II: Identify, develop, and prototype the most promising atom or molecular technologies, including the development of experimental applications to evaluate their effectiveness.

PHASE III DUAL USE APPLICATIONS: Successful results can be applied to improving test performance in numerous commercial and industrial test and process control applications, such as new materials, electronics, biotechnology and chemistry.

REFERENCES:
1. Atom Technology, Joint Research Center for Atom Technology (JRCAT), SAIT, extended abstract '96 JRCAT Symp0sium on Atom Technology pp 181-194.
2. Paper Abstract. 93-22. Ultimate Manipulation of Atoms and Molecules "A New Project" Kazunobu Tanaka (NAIR) The Japan Society of Applied Phvsics. 1993. http://www.jrcat.or.jp/rc/tana/tana-paper-abs.html
3. D31.109 Scanning Reflection Electron Microscopy Study of an Initial Stage of Layer-by-Layer Sputtering of Si(111) surface. H. Watanabe, M. Ichikawa (Joint Research Center for Atom Technology), POSTER session, March 18, 1996. http//flux.aps.org/meetings/BAPSMAR96/tocD.html
4. DTIC AD-A221 303, OPTICAL SOCIETY OF AMERICA WASHINGTON DC, Proceedings of the Topical Meeting on the Microphysics of Surfaces, Beams, and Adsorbates (3rd) Held in Salt Lake City, Utah on 27 February-1 March 1989
5. DTIC, AD-A122 446, VARIAN ASSOCIATES INC, PALO ALTO, CA. MBE in MOS Technology Applied to Speed Increases in VHSICs.

KEYWORDS: Molecular, Atom Technology, Nano Algorithms, Neural Networks, Genetic Algorithms, Automatic Test Equipment

AF99-310 TITLE: High Speed Digital Timing Sets and Pattern Generator

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop software to automatically create high-speed stimulus patterns and timing sets for LASAR.

DESCRIPTION: Conduct research to determine if it is possible to automatically develop high-speed timing sets, stimulus patterns and probe timing sets for LASAR on a personal computer platform. Applicable LASAR factors which the software might use are component primitives, circuit models, and I/O. Digital circuits are tested on Automatic Test Equipment using a LASAR generated software routine. Engineers develop the circuit model, stimulus patterns and timing sets, then LASAR processes this information into a test routine. The engineering task required to figure out the timing set and proper pattern routine for a complex digital unit could be prodigious. Many factors become critical and when the engineer is dealing with thousands of different signal variations and possibilities, mistakes can be made and problems can be compounded. When subtle timing problems exist within a timing set, the guided probe and fault dictionary routines can and will identify good parts as bad. Even-though, the go/nogo path might be stable, a diagnostic routine, which is used to detect defective parts, can miss changes in the node state logic when a trigger or input timing sequence is slightly inexact. The dynamic software package is needed to augment the engineer's skill and accomplish the proper fix to critical timing problems.

PHASE I: Develop a software approach that will demonstrate high-speed timing sets, stimulus patterns, and probe timing sets for LASAR models.

PHASE II:Develop an experimental software prototype of the approach(es) defined during Phase I.

PHASE III DUAL USE APPLICATIONS: Will provide resolution of major problems like retest-OK (RTOK), and could-not duplicate (CND) in aircraft equipment repair. Significantly improves LASAR test software development time. Significant commercial markets exist for this technology in industrial process control and medical process applications.

KEYWORDS: LASAR V6, Digital Circuit Testing, Automatic Test Equipment

AF99-312 TITLE: Automatic Rail Alignment Checker

TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: Provide a fast, accurate and independent method for verifying vertical and horizontal alignment of rails.

DESCRIPTION: Determine the effectiveness of an automatic rail alignment checker to provide quick status of the rail without relying on Defense Mapping Agency (DMA) surveys. Alignment of the rails is maintained through precision measurements and continuous adjustment of both horizontal and vertical rail alignment fixtures. Currently, the data obtained from Track surveyors has to be converted into track coordinates and compared to the rail fiducial line to obtain realignment settings to apply to each rail fixture. This process has to be repeated several times to minimize the rail alignment error. The checker is conceived as a towed sled which can travel over the rail to be inspected at speeds greater than 5 ft/s and accurately measure the rail at each interval to ±0.01 inch in both the vertical and lateral directions. The sled must carry the appropriate sensors and processing systems to efficiently collect and reduce the measurement data into information that can quickly determine the position of the rail immediately prior to a high speed sled test.

PHASE I: Design specialized sensors capable of measuring the position of the rail and rail fixtures and integrate those sensors with supporting hardware and software for a self-contained sled which can be towed on the rail and provide vertical and horizontal deviations to the fiducial line along the rail. Due to the extreme accuracy requirements, various measurement technologies, such as laser interferometry, will have to be advanced to provide a final product that satisfies all requirements.

PHASE II:Fabricate and test the automatic rail alignment checker to determine its accuracy, to establish operating and calibration procedures, to determine suitability and reliability for this application, and to make improvements, as needed, to provide quick, accurate reports of rail status to Track personnel.

PHASE III DUAL USE APPLICATIONS: The capability to assess the vertical and horizontal position of rails with respect to an established line can be applied wherever high accuracy is required or where other methods of establishing position are unavailable. Applications include high-speed trains, rail-mounted cranes or structures, and automated factories where robotic devices move on rails.

KEYWORDS: Fiducial Line, Rail Alignment, Horizontal and Vertical Deviations

AF99-313 TITLE: On-Line Engine Structural Vibrometer for High Cycle Fatigue (HCF) Turbine

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop a non-intrusive vibration measurement system for internal components of turbine engines (rotating blades, stator vanes, etc.).

DESCRIPTION: The goal is to directly measure component displacement and/or strain/stress over the whole surface of the component. The measurement system to be developed must provide an incremental improvement and a more direct physical measurement relative to the existing non-intrusive technique, the Non-Intrusive Stress Measurements System (NSMS). The

NSMS uses a light probe to detect the time-of-arrival of the blade tip and infers tip displacement based upon a model of where the blade tip should be versus where it is.

The proposed vibrometer system must be a small (i.e., ~0.5" diameter threaded sensor nose for engine case mount) and rugged apparatus with no Foreign Object Damage (FOD) potential for the turbine engine or test facility. No intrusion into the gas flow path and nothing that would affect the vibrational characteristics of the components under investigation will be allowed. Adverse environmental considerations include, but are not limited to, window contamination, vibration, and heat. The vibrometer system must detect rigid body motion and dynamic displacement from vibration. Complex engine geometry will require case access view from high incidence angles to completely scan the components of the inner engine stages (width controlled by stator rows between the rotating blade rows). Rotating blade view may be periodically blocked by other components. Penetration of the compressor case for access to the inner stages or other minimal internal component surface preparation may be allowed (i.e., mirrors by polishing). Rapid scanning for transients, to minimize aliasing of high frequency vibrational motion, will be required if a single snap-shot approach is not used. A single snap-shot of the whole blade is the preferred approach. High speed image/data analysis for on-line use is required.

Specific system requirements include operating temperature ranges of -60 to 350F (1st stage fan) and up to 2200F (turbine area), 12" X 6" maximum blade dimension (1st stage fan), 2" X 1" minimum blade dimension (final high pressure compressor (HPC) stage), and rotational rates up to 20,000 RPM. The captured blade view should provide a minimum resolution equivalent to 200x100 Pixels, with the 200 pixel resolution configurable for alignment with the longest dimension of the blade. Potential blade deflection ranges from 0.0005" (short stiff HPC) to 1.5" (long, wide fan) with a frequency range of 0 to 30KHz. Blade edges must be well defined such that displacement/modal patterns can easily be overlaid onto a blade outline for the given view. The final output should be blade displacements/mode shapes as a function of view that are also resolved to the component surface perpendicular direction. Imaging lasers shall not damage component material in any way.

PHASE I: A proof of concept demonstration of a candidate technique meeting the bulk of the above requirements and challenges shall be performed.

PHASE II: A prototype system is to be demonstrated for shaker table operation and on an operating turbine engine in one or more areas, i.e., fan, compressor and turbine.

PHASE III DUAL USE APPLICATIONS: The instrument to be developed will have commercial applications with the commercial aircraft turbine-engine manufacturing industry as well as with the power generation industry. It will be applicable to both conventional steam turbines and stationary gas turbines.

REFERENCES:
1) Srinivasan, A.V., "Flutter and Resonant Vibration Characteristics of Engine Blades," Transactions of the ASME, Journal of Engineering for Gas Turbines and Power," vol. 119, pg 742-775, October 1997

2) K. L. Nichol , M. D. Sensmeier, and T. F. Tibbals, "Development of the Structural Dynamic Response Analysis Capability," Proceedings of 3rd National HCF Conference, San Antonio, Tx, February 2-5, 1998

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Vibrometer, Test Facility, Turbine Engine, Blade deflection, High Pressure Compressor

AF99-314 TITLE: Temporally and Spatially Resolved Spectrograph for 15-300 keV X-Rays

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop an instrument to measure the x-ray dose and spectrum over a large surface area at the position of a test object with spatial and temporal resolution.

DESCRIPTION: Making high accuracy temporal measurements of both spectral and spatial resolution of a flash x-ray simulator radiation-output are extremely difficult. Current detectors sacrifice resolution, or do only spectral or spatial resolving of radiation output. There is a need to make these measurements simultaneously with a high degree of resolution. The DECADE quad x-ray simulator irradiates a test object with radiation produced by four separate diodes that combine over the entire test area. The effective dose, dose-rate, and spectral hardness of the radiation are thus a combination of those four diode's radiation time histories. An instrument to measure the effective radiation on a test object would be extremely useful. The initial radiation source (MBS) for this measurement would be on the order of a mcal/cm2, a 30-40 nsec pulsewidth, and an area of 100 cm2. The goal is to then scale up to the DECADE radiation source of 20 krad (Si), 40-50 nsec pulsewidth, and 2500 cm2 area. Specifics for such a detector are
(1) Spatial Resolution - less than 5 mm

(2) Temporal Resolution - less than or equal to 2 nsec
(3) Spectral Resolution - 10% energy differentiation
(4) Data from the detector would be acquired by 224
channels of modified Analytek digitizers are on site
(5) Initial operation area for the detector would be 100
square centimeters
(6) Final operation area for the detector would be 2500
square centimeters

Development of the detector would include a software package for unfolding spectral and spatial data as well as error analysis of the instrument and a sensitivity matrix of all channels. The instrument would be required to be radiation tolerant or provide for calibration before each use as well as allow for easy replacement of radiation damaged components.

PHASE I: A concept demonstration and evaluation of the proposed instrument on the MBS shall be performed.

PHASE II: Fabricate, test, and deliver to AEDC a full scale instrument for use on the DECADE radiation source.

PHASE III DUAL USE APPLICATIONS: The commercial applications would be in the medical imaging and radiation therapy fields where precise spatial knowledge of the x-ray dose is required. There is also interest in the high energy physics and accelerator community for spatial information of x-rays and other ionizing radiation. There may be uses in x-ray inspection of aircraft parts and in other x-ray inspection applications.

REFERENCES:
1) T.Ohkoshi, "Fundamentalsof Optical Fiber," OHM, 1-17 (1977)
2) H. Murata, "Handbook of Optical Fibers and Cables," Marcel Dekker, Inc 1996
3) F. Kapron, D. Keck, and R. Maurer, "radiation losses in glass optical waveguides," Appl. Phys. Lett., 17:423-425, Nov 1970
4) J. Hecht, "Understanding Fiber Optics," Sams Publ. 1993.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: X-Rays, Ionizing Radation, Spatial Resolution, Spectral Resolution, Flash X-Rays Simulator

AF99-315 TITLE: Fiber Optics Technology Application to Combined Temperature and Stress Measurement

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop a miniaturized Instrumentation System using Fiber Optics Technology for combined measurement of strain and temperature in wind tunnel or turbine engine test applications.

DESCRIPTION: In a recent Symposia of the Instrument Society of America (ISA) a novel approach to the measurement of strain using Bragg and Long Period Gratings was reported. This technique has potential application to balance technologies; increased sensitivity in a compact integrated sting/balance structure appears possible. Reference 1 focuses on the use of Bragg gratings and Reference 2 focuses on the use of long period gratings and describes a technique using higher order wave attenuation bands to simultaneously solve for temperature and strain. The Bragg grating has significant temperature sensitivity. The temperature sensitivity of a long period grating can be worse if special design considerations are not incorporated. A technique to produce a doped fiber and attendant calibration methodology that can be used to simultaneously make temperature and strain measurements of sufficient accuracy to be incorporated into a balance and measurement system is needed.

The balance system (balance, instrumentation, software, calibration technique) for the Wind Tunnel Application requires a one-piece sting-balance combination where the balance element is circular in cross-section and is an integral extension of the sting. Miniaturization is vital (diameter of less than an eighth of an inch with a working stress of 1/3 yield). Furthermore, accuracy of stress measurement to better than 1% is needed over the temperature range of 40 to 160 degrees f, and temperature resolution and accuracy better than 1 degree and 2 degrees f, respectively, is needed.

The measurement system for Engine Test Application, that will permit measurement of stress and temperature of turbine engine components during operation, requires the ability to measure stress and temperature with accuracy of better than 1%. These measurements will be made over a temperature range of 400 to 2300 degrees F. The limitations of utilizing doped fibers may preclude the application of fibers with doped gratings to this range of temperatures. In this event, other fiber-optics applications will be considered. The capability to make stress and temperature measurements on rotating elements such as turbine blades is desirable.

Wind Tunnel Application:

PHASE I: Demonstrate experimentally the ability to produce a fiber optic strain PHASE Ibalance with temperature compensation for use in adverse thermal environment.

PHASE II: Develop and deliver a 1/8-inch diameter integral sting-model balance that is fiber optic sensor based with measurement capability for forces and moments about three orthogonal axes.

Turbine Engine Test Application:

PHASE I: Experimentally demonstrate the ability to produce a fiber optic-based combined strain and temperature measurement in an adverse thermal environment

PHASE II:Develop and deliver a fiber optic sensor based sensor to measure strain and temperature within the turbine engine environment.

PHASE III DUAL USE APPLICATIONS: The commercial market for such a device is extensive. The ability to measure stress and temperature simultaneously has many applications in the aerospace community as well in other industries such as automotive and chemical processing.

REFERENCES:

1) Fiber Optic Sensors For Structural Monitoring, Kersey, A.D., et. al, ISA, 1997, 0227-7576/97/747-756, Orlando, Fla., May 4-8, 1997

2) Grating Based Optical fiber Sensors for Machinery Monitoring, Nemarich, Christopher, et. al, ISA, 1997, 0227-7576/97/727-738, Orlando, Fla., May 4-8, 1997

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Fiber Optics, Bragg Grating, Balance System, Stress Management, Strain Measurement, Long Period Grating

AF99-318 TITLE: Digital High-Speed Imaging Technologies-Hypersonic Wind Tunnel Support

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop an imaging device capable of producing high resolution planar-images at rates of up to 1 million frames per second.

DESCRIPTION: Evaluation of the performance of new hypersonic wind tunnel technologies will require high-speed diagnostics to follow the high frequency effects associated with the fluctuations in these high-speed flows. A system capable of digitally imaging flows at MHz rates is needed. The device must have high sensitivity in both the ultraviolet and visible portion of the spectrum. The imaging device will be used in conjunction with various laser diagnostic approaches including Rayleigh scattering, laser-induced fluorescence, shadowgraphs, and Schlieren techniques. The desired apparatus should provide:

1. High energy laser pulses with a few tens of nanosecond pulse-width
2. MHz rep-rates.
3. A laser that operates in a burst mode with several milliseconds of pulses per burst.
4. A digital recording system/camera capable of producing high quality images that give spatial information on flow properties such as density and are capable of following shock wave and boundary layer fluctuations.

The laser and camera/recording system must be reasonable in size, simple to operate, and extremely reliable.

PHASE I: A concept demonstration of a controllable MHz rate laser and digital camera/recording system will be performed.

PHASE II: Manufacture, deliver to the Arnold Engineering Development Center (AEDC), and demonstrate a laser and digital camera/recording system in an AEDC test facility.

PHASE III DUAL USE APPLICATIONS: The commercial market for such a device is extensive. The device would have applications in all high-speed aircraft/missile test facilities. Private testing laboratories could use the device in dynamic failure analyses.

REFERENCES:

1) Lempert, W.R., Wu, P.F., and Miles, R.B., "Filtered Rayleigh scattering measurements using a MHz rate pulse-burst laser system," AIAA Paper 97-0500, 35th Aerospace Sciences Meeting, Reno, NV, Jan 6-9, 1997.

2) Lempert, W.R., et al, "Pulse-burst laser system for high-speed flow diagnostics," AIAA Paper 96-0179, 34th Aerospace Sciences Meeting, Reno, NV, Jan 15-18, 1996.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Resolution, Sensitivity, Planar-Images, Spatial Information, Digital High-Speed Imaging

AF99-319 TITLE: High Temperature Probe Blade Tip Clearance Measurement System

TECHNOLOGY AREA: Aerospace Propulsion and Power

OBJECTIVE: Develop a sensor for measurement of blade tip clearances in operating turbine engines with the capability to measure absolute clearance of individual blades.

DESCRIPTION: Excessive clearance between rotating blade tips and the stationary case of gas turbine engines can seriously degrade engine efficiency and performance. Capacitance probe systems are used to measure the blade tip clearances in operating turbine engines, but improvements in these systems are required to meet future engine development and diagnostic needs. Shortcomings of present systems include: poor probe lifetime at typical operating temperatures of 1400 F to 3000 F, difficult to install because of cable size, stiffness and length restrictions, cannot measure absolute clearances, cannot measure when engine is stopped or running at low speed, poor performance on shrouded rotors, systems read only average clearance, but individual blade clearance information is needed to obtain rotor dynamics data.

PHASE I: A proof-of-principal demonstration, showing system response capable of measuring individual blade clearance, will be performed.

PHASE II:A prototype blade tip clearance system with response capable of measuring individual blade clearance in turbine engines at operating temperatures of 1400 F to 3000 F.

PHASE III DUAL USE APPLICATIONS: The commercial market for such a device is large. Availability of robust blade tip clearance probes and signal processing electronics would greatly assist development of active clearance control systems and engine conditioning monitoring systems for production engines. In addition to flight engines, the market for this technology also includes stationary turbine engines used for electric power generation.

REFERENCES:
1) Sheard A. G., "Blade By Blade Tip Clearance Measurement in Aero and Industrial Turbo Machinery," Instrument Society of America, ISA Paper 91-080, 1991
2) A.G. Sheard, "Capacitive Measurement Of Compressor and Turbine Blade Tip To Casing Running Clearance," American Society of Mechanical Engineers, ASME Document 96-GT-349, 1996

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Blade Tip, Tip Clearance, Capacitance Probe, Gas Turbine Engines, Active Clearance Control

AF99-323 TITLE: IDEF3 Based Training

TECHNOLOGY AREA: Manpower, Personnel, and Training

OBJECTIVE: Continuous training improvement concurrent with continuous process improvement.

DESCRIPTION: One of the major challenges of continuous process improvement is the concurrent propagation of process change to the process personnel training material. Air Force's IDEF3 Process Description Capture Method is a very rich and robust method for capturing process knowledge, and used widely for process reengineering and improvement. Process descriptions in IDEF3 contain the basic knowledge needed by personnel to perform the process. However, the IDEF3 format and span of knowledge may not be needed by all process personnel. In addition, without training in the IDEF3 method, the IDEF3 format of process knowledge may not be used by the average process worker. The successful proposal shall develop a commercially viable extraction of the IDEF3 process knowledge that is selected and delivered in a format that trains and assists process workers in their duties.

PHASE I: Demonstrate extraction of IDEF3 method knowledge and presentation in two or more formats.

PHASE II: Complete the development of the Phase I demonstration into a robust commercial training delivery system which can vary the content of knowledge and the format of delivery as needed by process personnel.

PHASE III DUAL USE APPLICATIONS: This technology has immediate application in all businesses because all businesses have process change and all businesses need personnel trained and retrained. This technology will improve the accuracy and timeliness of training to organizational personnel.

REFERENCES:

1) Mayer, R. J., et al. (1992). IDEF3 Process Description Capture Method Report AL/HR/TP-1992-0057, ADA252 633, Wright-Patterson AFB, OH: AL/HRGA.
2) Mayer, R. J., et al. (1994, in press). Ontology Capture Method (IDEF5) AL/HR/TP-1994-0029, ADA288442, Wright-Patterson AFB, OH: AL/HRGA.
3) Mayer, R.J., et al. (1997). IDEF3 Process Description Capture Method Report; AL/HR-TP-1996-0030, ADA329 632. Wright-Patterson AFB, OH: AL/HRGA.

KEYWORDS: IDEF3, Modeling, Training, Knowlege Delivery

AF99-324 TITLE: Advanced Multi-function Integrated Target Subsystem (AMITS)

TECHNOLOGY AREA: Air Vehicles/Space Vehicles

OBJECTIVE: Develop a reduced cost, integrated aerial target subsystem to perform command/ control, autopilot, tracking, inertial, scoring and digital bus interface functions.

DESCRIPTION: The Air Force uses remotely piloted vehicles (or drones) as targets to test the effectiveness of airborne weapons. These aerial targets, either full scale or sub-scale in size, are configured and instrumented to replicate real world enemy aircraft. Current target vehicles must employ multiple subsystems to accomplish the command/ control, autopilot, tracking, inertial, scoring and digital bus interface functions. This multiple subsystem approach is expensive and requires excessive volume, creating a need to carry external pods. The use of external pods changes the multi-spectral signature of the target, thereby degrading the capability to replicate the various aircraft threats. Additionally, the use of pods on small subscale aerial targets severely degrades flight performance. Innovative approaches (including miniaturization, functional consolidation, and new technology insertion) are required to reduce system costs and the volume used by current subsystems. These innovations should eliminate the need for external pods through internal vehicle integration. Many technical challenges need to be addressed, including: (1) the command/ control data link must support long distances, over the horizon, with very low latency secure duplex digital data transfer; (2) common Tri-Service microprocessor architecture to perform the large amount of onboard computations is under consideration; (3) software written for older processors needs to be integrated into the common architecture; (4) Global Positioning System (GPS) and GLONASS (Russian GPS) data processing capability must be integrated to provide accurate tracking even in the presence of intentional GPS jamming; (5) cooperative target and missile GPS scoring capability is needed that can provide precision tracking in the high speed and high "g" air combat terminal environment; (6) low cost, tightly coupled GPS/ inertial capabilities are needed to eliminate the need for gyros and altimeters; (7) low cost digital bus capability to reduce wiring bundles; and (8) commercial technology needs to be adapted into an environmentally stressful military test and training application to reduce cost.

PHASE I: Research appropriate technologies, define innovative concepts/ approaches and perform technical and cost trade-off analyses. Determine hardware/ software requirements and evaluate critical components. Document results and prepare validation test plan.

PHASE II:Perform integrated system functional evaluation. Design, develop, produce and integrate a prototype AMITS unit into an aerial target. Validate performance and document results.

PHASE III DUAL USE APPLICATIONS: Commercial applications include use in industries that involve robotics and remotely controlled vehicles, such as manufacturing and sophisticated toys.

REFERENCES:

1) Advanced Avionics Subsystem and Technology (AAST) Backplane Bus Protocol IC, DN100195, Sep 1993
2) Yoder, Thomas L., The Use of Iridium, a Commercial Telecommunications Satellite System, in Wartime, AD-A312 259, June 1996.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Command, Scoring, Autopilot, Aerial Targets, Multi-Processor, Integrated Electronics, GPS and Inertial Reference, Control and Communications

AF99-325 TITLE: Onboard Smart Sensors

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop sensors, which can interactively communicate with (existing and future) onboard instrumentation controllers.

DESCRIPTION: The time and effort necessary to track sensor inventory and calibration for onboard systems can be extensive. An alternative is to have sensors which, when queried, can respond with all the 'vital statistics' regarding their functionality - e.g., whether they are working, what their calibration information is, what their serial number is, or simply what they measure. This would allow an instrumentation system to know exactly what is available on a test vehicle which, in turn, would allow the coordination of the instrumentation setup and the ground station setup for a test to be significantly simplified. Additional desired capabilities include generation of simulated output and autocalibration (changing the calibration coefficients in real-time). This would allow full pretest checkout and dynamic error correction which, in turn, would decrease maintenance and increase quality. The IEEE P1451 committee is establishing a standard [1] for smart sensors but there are few companies fully engaged in developing such instrumentation. A successful smart sensor would not only meet P1451 standards but would also be able to be linked into existing instrumentation systems (e.g., AATIS, CAIS, etc.). Sensors must be small and ruggedized to meet onboard requirements. Part of the emphasis here is that sensors need to be not only smart, but also versatile enough to be integrated into many different systems. They need to be compatible with the emerging smart sensor networks but also need the transitional ability to work with existing systems. That is, the designs should apply open architecture and plug and play technologies.

PHASE I: Research and analyze designs of smart sensors which can be used across existing instrumentation systems as well as meet IEEE P1451 standards. Provide a final report of analysis and recommendations.

PHASE II: Build prototype sensors. Test prototypes in ground based and airborne tests at the Air Force Flight Test Center, Edwards AFB, California.

PHASE III DUAL USE APPLICATIONS: Smart sensors are the 'plug and play' devices of instrumentation systems. IEEE has a proven track record for establishing standards that are used industry wide. An approved version of the P1451 standard is expected to be released soon and should instigate a wave of development of smart sensors. Thus, there is strong potential for such devices to be marketable to almost any user of data acquisition systems.

REFERENCES:
1) "IEEE P1451.2 D2.01 IEEE Draft Standard for A Smart Transducer Interface for Sensors and Actuators - Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats," Institute of Electrical and Electronics Engineers, August 1996
2) Lee H. Eccles, "A 'Smart Sensor' Bus for Data Acquisition," Proceedings of the International Telemetering Conference (ITC), Vol. XXXII, 1996 paper number 96-05-3.
3) Fernando Gen-Kuong and Alex Karolys, "Smart Sensor Network System," Proceedings of the International Telemetering Conference (ITC), Vol. XXXIII, 1997 paper number 97-03-1.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Telemetry, IEEE P1451, Smart Sensor, Instrumentation, Data Acquisition

AF99-326 TITLE: Laser Tracker Location Detection Capability

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop a capability to detect the location of a targeting laser spot and its power within an existing Installed Systems Test Facility (ISTF).

DESCRIPTION: Many current and future weapon systems utilize laser targeting and tracking technologies. These weapon systems will be tested in an existing ISTF at Eglin AFB, Florida. The Air Force needs the ability to: (1) determine tracking sensor and laser line of sight accuracy requirements; (2) measure laser pulse codes; and (3) model atmospheric effects and simulate laser ranging for weapon systems that use different laser wavelengths and power. Additionally, facility vulnerability analysis is required to determine the effects of lasers with different wavelengths and power operating within the test chamber. System and personnel safety issues, such as laser power status and laser spot location, must be evaluated and capabilities developed to prevent hazardous conditions. Technical challenges include developing methods for tracking sensor and laser line of sight accuracy, replicating laser pulse coding techniques, and simulating atmospheric effects and laser ranging.

PHASE I: Research appropriate technologies, establish innovative concepts/approaches, perform trade-off analyses, and define hardware/ software/ safety/ and integration requirements for use in existing ISTF. Prepare validation test plan and document results.

PHASE II:Design, develop, produce and integrate a prototype system within the existing ISTF. Validate and document the results and the method of operation.

PHASE III DUAL USE APPLICATIONS: Commercial applications include laser range finders, automated tollbooth detectors, automated heavy equipment control and automated highway systems.

REFERENCES: Deis, Michael, PRIMES Users Manual, May 1998.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: LANTERN, Laser Ranging, PRIMES Facility, Laser Targeting, Laser Detection

AF99-328 TITLE: Avionics Sensor-based System Interoperability with Knowledge-based System Applications

TECHNOLOGY AREA: Computing and Software

OBJECTIVE: Develop technology for interoperable and cooperative knowledge-based systems in weapon system and support applications.

DESCRIPTION: Develop software to translate sensor information from automatic test equipment into a common data format whereby the sensor data can be transported to a personal computer platform for evaluation. Advances in two areas are creating opportunities for new and diverse methods for improving weapon system and support equipment effectiveness. Advances in multi-sensor fusion are providing new methods for combining and interpreting passive and active sensor information in areas ranging from non-cooperative target recognition to geological mineral assessment. Technologies used to process this information include neural networks, generic algorithms, wavelets, fractals and the like. Communication technology advancements are providing new and increased capabilities for easily sharing data and information amongst geographically distributed sites using satellites, wide area networks, and the Internet. These combined capabilities can pave the way for the development of new approaches and techniques for utilizing remote sensor information cooperatively amongst interoperable distributed systems to perform various support tasks. Software which formats sensor data into a common data format promotes remote interpretation of test and sensor signal data communicated through the Internet and other means.

PHASE I: Design a prototype application of sensor data interpretation and formatting to demonstrate their effectiveness for evaluation on a personal computer platform. Develop methods for combining into current Air Force support practices.

PHASE II: Develop prototype software and combine methods into existing Air Force support processes. Evaluate program results for their utility and effectiveness in enhancing Air Force support capability.

PHASE III DUAL USE APPLICATIONS: Potential exists for the application of interoperable cooperative knowledge-based systems in the military, commercial and industrial sectors in process control, intelligence, geological survey, medicine, automobile, aircraft and numerous other sensor fusion applications. Additional opportunities exist in law enforcement, insurance, banking, and financial industries where large amounts of data needs to be examined at geographically distributed sites.

REFERENCES:
1. Kirkland, L.V., "ATE Enabling Technologies", AUTOTESTCON 94' Anaheim, California, 21-24 September, 1994.

2. IEEE P1391 - Standard for Software Interfaces for Knowledge-based System Interoperability in Sensor-based Processing Applications
3. NORTH ATLANTIC TREATY ORGANIZATION BRUSSELS (BELGIUM), Executive Summary of the Technical Report on Distributed Systems Modeling Emphasizing Object-Orientation. Defense Research Group Panel 11 on Information Processing Technology. Research Study Group1 on Distributed System Design Methodology, Jan 1994.

KEYWORDS: Sensor-Fusion, Neural Networks, Genetic Algorithms, Emerging Software Tech, Automatic Test Equipment

AF99-330 TITLE: Automatic Conversion of Conventional Tabled Aerodynamic Models

TECHNOLOGY AREA: Modeling and Simulation

OBJECTIVE: Develop a computer algorithm to automatically scan and convert aerodynamic table lookup models into spline models or another form suitable for use with modern nonlinear Parameter Identification (PID) methods and simulation.

DESCRIPTION: Modeling and simulation (M&S) is becoming a large force in flight testing. In order to apply the theoretical advantages of M&S, model updating is required. Modern nonlinear parameter and systems identification programs do not work well with conventional total force and moment coefficient, table lookup aerodynamic models. These models are used in simulations due to their computational simplicity and ability to use linear interpolation and extrapolation. Unfortunately, these models are difficult to directly update based on flight test results. Modern nonlinear parameter identification(ID) methods work well with polynomial equations used for describing the forces and moments. Unfortunately, these models do not necessarily work well in simulation. A methodology which uses a hybrid of the two above techniques has shown promise for both use in simulation, and nonlinear parameter ID methodologies, this is the 'spline model' technique. The nonlinear forces and moments are described as a series of polynomials over a range of independent variables. Another promising technique is using multivariable orthogonal functions to describe analytic representations of the nonlinear aerodynamics.

Current and most future aerodynamic simulation models are, and will be, of the old total coefficient table lookup type. Modifying these models to a form suitable for nonlinear PID from flight test data is time consuming and expensive. Conversely, modifying flight test results to fit these table type look-up models is also time consuming and expensive. The cost in time and manpower hampers and slows down the ability to update aerodynamic models based on flight test results. A computer algorithm which will automatically convert a conventional table lookup model to a spline model, or another form suitable for applications of nonlinear Parameter ID methods as well as direct simulation use is required. Without this ability, full use of M&S benefits in flight testing will not be realized.

PHASE I: Investigate suitable formats for aerodynamic models and select one which is easily updated from flight test data using PID methods and a conversion algorithm to translate between this form and the conventional form used in simulation.

PHASE II:Construct a prototype application and demonstrate it at the Air Force Flight Test Center, Edwards AFB, California. The demonstration application will be evaluated to determine how well it satisfies the AFFTC requirements.

PHASE III DUAL USE APPLICATIONS: This solution has wide application to dynamic system modeling. The ability to easily update aerodynamic models directly from flight test has application in both defense and commercial related fields. It is envisioned that the ability to directly update model parameters from experimental data can be applied to a wide range of fields including; engineering, physics, chemistry, biology, etc. The mathematics and techniques required will be applicable to the modeling and simulation of any dynamic system. Modeling and simulation use in science and engineering is exploding as computer technology expands. The results of this solution could be used by any military, government, or commercial organization which requires accurate, updated systems models based on actual systems test results.

REFERENCES:
Klein, Vladislav: Determination of Airplane Model Structure From Flight Data Using Splines and Stepwise Regression, NASA Technical Paper 2126, 1983.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

KEYWORDS: Flight Test, Spline Models, Aerodynamic Modeling, Stability and Control, Parameter Identification

AF99-331 TITLE: Distributed Beam Steering Controller

TECHNOLOGY AREA: Electronics

OBJECTIVE: Demonstrate that completely independent small, low cost, flexibly programmed, general purpose controllers allow beam steering of wide-band, modular, extensible and scalar phased array antennas.

DESCRIPTION: Phased array antennas consist of multiple stationary antenna elements, which are fed coherently and use variable phase or time-delay control at each element to scan a beam to given angles in space. The primary reason for using arrays is to produce a directive beam that can be repositioned (scanned) electronically. Phased array antennas allow precise beam patterning. They are complicated assemblies of radiating and receiving elements, phase shift networks, control electronics and a powerful computer that computes the required phase shift and time delay, if needed, at each element. This information is passed to individual or group decoders which drive the phase shifter and time delay units. The computer has knowledge of the physical topology of the phased array elements and the available phase shifts and time delays. The frequency of interest is also known. The steering commands are in terms of phase shift and time delays but the actual computation depends solely on time differences. Thus the phase shift is actually a function of the frequency of interest. All of this is currently accommodated by the out-of-date beam steering computer. These functions could be accomplished in a highly cost/weight effective manner through the application of a high density single chip computer, phase shift driver, and time delay driver, that is small, modular and flexible. This computer would make the computations based on a knowledge of the geometry of the phased array and the frequency of interest.

PHASE I: 1) Design a high density single chip phase shift and time delay controller that implements classical steering algorithms. Ensure that the hardware design of the controller incorporates only that hardware needed to execute the functions used by the specifics of a steering algorithm. 2) Fabricate a breadboard of the controller and demonstrate functionality.

PHASE II: 1) Finalize controller design. 2) Fabricate a prototype controller(s) using commercial processes. 3) Demonstrate functionality of the prototype commercial controller in accord with mutually agreed-upon requirements.

PHASE III DUAL USE APPLICATIONS: Antennas that can electronically point their beam are applicable to all of the existing and emerging communications systems. Agile steerable beams allow more channels in a geographical area. Such uses are for cell phones, personal communication systems (PCS), wireless modems, point of sale terminals, pagers. A successful high density single chip computer and phase shift driver as described in this project would be in high demand for commercial communication systems.

REFERENCES:
1. Phased Array Antenna Handbook (Artech House Antenna Library) by Robert J. Mailloux. ISBM: 0890065020.
2. Practical Phased-Array Antenna Systems by Eli Brookner (Artech house Publication, August 1991) ISBN: 0890065632.